

**The role of  
Business Model Innovation:  
in transitioning ULEVs To Market**

**by**

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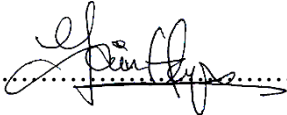
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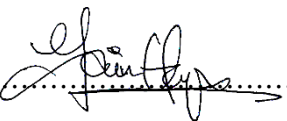
## Candidate's Declarations

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### STATEMENT 1

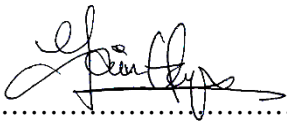
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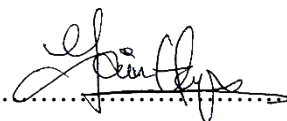
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## List of Acronyms & Abbreviations

AFIGP	-	Alternative Fuels Infrastructure Grant Programme
APX	-	Aluminium Performance Crossover (Lotus Concept Platform)
AVID	-	AVID Vehicles, Part of the AVID Group Ltd.
BCG	-	Boston Consulting Group
BIS	-	Department for Business Innovation & Skills
BM	-	Business Model
BMC	-	British Motor Corporation
BRIC	-	Brazil, Russia, India, China
BYD	-	Build Your Dreams (Chinese VM)
CABLED	-	Coventry and Birmingham Low Emission Demonstrators [Programme]
CAQDAS	-	Computer Aided Qualitative Data Analysis
CEDA	-	Comprehensive Environmental Data Archive
CENEX	-	CENtre of EXcellence (for Low Carbon & Fuel Cell Technologies)
CKD	-	Completely Knocked Down
CM	-	Contract Manufacturer
CNA	-	Citation Network Analysis
CRM	-	Customer & Relationship Management
CUTE	-	Clean Urban Transport for Europe
CO <sub>2</sub>	-	Carbon Dioxide
DBERR	-	Department for Business, Enterprise & Regulatory Reform [Now Defunct]
DDT	-	Dichlorodiphenyltrichloroethane (Pesticide)
DECC	-	Department for Energy & Climate Change
DEFRA	-	Department for the Environment, Food & Rural Affairs
DERV	-	Diesel Engined Road Vehicle [Diesel Fuel]
DETR	-	Department for Environment Transport & The Regions [Now Defunct]
DFE	-	Design for Environment
DTI	-	Department for Trade and Industry [Now Defunct]
DUKES	-	Digest of UK Energy Statistics
DVD	-	Digital Versatile Disc

ECC	-	Electric Car Company
EST	-	Energy Saving Trust
ETI	-	Energy Technologies Institute
GDP	-	Gross Domestic Product
GHG	-	Greenhouse Gas
GMD	-	Gordon Murray Design
GPS	-	Global Positioning System
GREET	-	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation
GRP	-	Glass Reinforced Plastic
GRS	-	Ginetta Built Estate Car
GVW	-	Gross Vehicle Weight
H <sub>2</sub>	-	Hydrogen
ICE	-	Internal Combustion Engine
ICEV	-	Internal Combustion Engined Vehicle
ICT	-	Information & Communication Technology
IEA	-	International Energy Agency
IGP	-	Infrastructure Grant Programme
ImPACT	-	Impact = Population x Affluence x Consumption x Technological Efficiency
IPAT	-	Impact = Population x Affluence x Technology
IPCC	-	Intergovernmental Panel on Climate Change
JIT	-	Just in Time
JLR	-	Jaguar Land Rover
LCA	-	Life Cycle Analysis
LCEA	-	Low Carbon Economic Area
LCV	-	Low Carbon Vehicle
LCVPP	-	Low Carbon Vehicle Public Procurement Programme
LHD	-	Left Hand Drive
LLP	-	Limited Liability Partnership
LNT	-	Lawrence Neil Tomlinson (Founder of LNT Group)
LPG	-	Liquefied Petroleum Gas
MAXQDA	-	MAX Qualitative Data Analysis (Software)

MFA	-	Material Flow Analysis
MDI	-	Motor Development International
MIRA	-	Now MIRA Ltd. Formerly the Motor Industry Research Association
MNC	-	Multi National Corporation
MPG	-	Miles Per Gallon
MPH	-	Miles Per Hour
NAIGT	-	New Automotive Innovation and Growth Team
NAREC	-	National Renewable Energy Centre
NPD	-	New Product Development
NVN	-	Niche Vehicle Network
OECD	-	Organisation for Economic Co-operation & Development
ONE	-	ONE North East
OSCar	-	Open Source Car
QFD	-	Quality, Function, Deployment
RAC	-	Royal Automobile Club
RDA	-	Regional Development Agency
RMI	-	Rocky Mountain Institute
SAE	-	Society for Automobile Engineers
SD	-	Sustainable Development
SCP	-	Sustainable Consumption & Production
SIC	-	Standard Industry Code
SME	-	Small – Medium Enterprise
SMMT	-	Society of Motor Manufacturers & Traders
SNM	-	Strategic Niche Management
SRKB	-	Shared Re-usable Knowledge Bases
SSM	-	Softy Systems Methodology
STS	-	Socio-technical Systems
TNC	-	Trans National Corporation
UKTI	-	UK Trade & Investment
ULEV	-	Ultra Low Emission Vehicle
VM	-	Vehicle Manufacturer

VMT	-	Vehicle Miles Travelled
VVA	-	Variable Vehicle Architecture
WWF	-	World Wide Fund for Nature
ZEV	-	Zero Emission Vehicle

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## Abstract

This thesis explores whether ‘business model innovation’ could hold the key to advancing the ultra-low and zero carbon vehicle industry in the United Kingdom.

This thesis presents a critical comparison of two case studies drawn from qualitative research conducted with a broad cross-section of UK vehicle manufacturers (VMs) that are interested in introducing zero carbon vehicles to the marketplace. The two cases, looking at large established producers of vehicles with trans-national presence (herein termed TNC/MNC VMs) and smaller producers (herein termed SME VMs).

The two cases consist of a number of grouped embedded cases focusing on the activities of vehicle producers that are in the process of introducing Ultra-Low Emission Vehicles (ULEVs) to the UK marketplace. These cases are constructed and informed by both primary research, semi-structured interviews conducted with representatives of these VMs, secondary analysis of interviews conducted with VM representatives and industry commentators and documentary analysis of contemporary sources and industry commentary.

The thesis is framed within a broader academic debate regarding the nature of achieving socio-technical transitions. Within this frame of reference, particular attention is paid to the role of large incumbents vs. new start-up insurgents in bringing innovative technologies to the marketplace; innovative technologies being seen as a key component of a transition to a more sustainable world.

In comparing the business models of large, well-established vehicle manufacturers, with smaller, newer, SME providers the ontology of Business Models developed by Osterwalder & Pigneur (2002) is used to interrogate, analyse and make comparisons between the business models of a range of companies that are very dissimilar in nature. Context is crucial to understanding the detail of case studies; as such, the thesis is also informed by the perspectives, gained through interviews, of a number of industry commentators, representatives of government organisations and automotive trade bodies.

This thesis set out to explore a number of research themes and the contributions to knowledge that this thesis has made are:

Establishing a theoretical linkage between Geels (2006) multi-level perspective of transitions literature and Osterwalder & Pigneur's (2002) business model ontology. By bringing these two powerful tools together, it is proposed that a complimentary analysis of the business model on the micro level, embedded within an overall socio-technical transition at the macro level can be made.

Furthermore, through an empirical analysis of business models in the car industry, a range of business model components, new directions for business models and "complementary" ancillary business models that support the introduction of ULEVs has been identified.

Disappointingly, whilst some observation are made about the early stages of transitions, the slow uptake of ULEVs in the marketplace has shown that the incumbent regime is still resistant to transition – and no concrete transition mechanisms can be identified. There are however a collection of observations about the early stages of socio-technical transitions.

The thesis also contributes to the ongoing debate about the tensions between incumbent and insurgent business contributing to the ongoing characterisation of the competitive forces that exist between them.

Another important contribution to the business models literature, is a discussion of the role of product, process and business model design. Very recent work by Meertens, Starreveld, Iacob, & Nieuwenhuis (2013) has also explored this issue, however, this work takes a different perspective informed by the empirical data within the case studies.

## Chapter I:

### Introduction

*“Never in the history of the automotive industry has the attention of so many been focused on the production of so few”*

---

Interview with Martin Ward, CAP – after Winston Churchill

#### 1.1 The Drive towards Sustainable Mobility

The quest for more sustainable forms of mobility is one of those beguiling challenges that continue to frustrate policy makers and mobility providers alike. Whilst there is an array of alternative pathways to reducing the impacts of transportation (Banister, 2008, p. 75), this thesis concentrates on the efforts of vehicle manufacturers to develop Ultra Low Emissions Vehicles (ULEVs). A range of UK firms seeking to introduce Ultra Low Emission Vehicles (ULEVs) are examined. These ULEVs are one of the responses of the established large, high volume, multi-national vehicle producers (which collectively form the majority of the industry by volume) to a range of environmental challenges, notably climate change & energy security. However, alongside their efforts, there is a parallel narrative of smaller, low volume companies, some long-established, but others that are newer entrants to the marketplace that are seeking to address the same challenge of bringing ULEVs to market. Both are a response to the challenges of reducing the environmental impact of transport behaviours. In order to ‘situate’ the contribution ULEV’s could make to sustainable mobility, this thesis will look at the concept of ‘sustainability’ in this section. Through a discussion of sustainable development, sustainable production & consumption and industrial ecology, the continuation of this chapter will locate the idea of ULEVs as being part of a journey towards minimising the impact of the transport sector on the environment. This is done with a critical view that ULEVs can only be part of a transition to sustainable mobility but nonetheless a necessary component. Whilst they only represent a partial solution, even this presents significant challenges. Even after decades of research and development (Rajashekara, 1994; Chan, 1999), the promise of ultra-low emissions is elusive (Cassell, 2009, p. 57) and, whilst ultra-low emission vehicles have been demonstrated variously in prototype, limited release and early market forms, their widespread adoption and unfulfilled promise seems always ‘just over the horizon’.

### 1.1.1 Sustainability

To unpick the present understanding of sustainability, it is helpful to understand how sustainability and the environmental movement(s) which brought the term to prominence have evolved. Different events have been catalytic in shaping awareness and defining sustainability, and there are a number of reviews that chart landmarks in the development of sustainability (Visser & van Heel, 2009) (Worldwatch Institute, 2004). One of the most complex and comprehensive timelines of the history of sustainability has been developed by Djalali & Vollaard (2010). Given the breadth of disciplines which have contributed to the sustainability discourse and taking into account the long history of different ideas that have been assimilated into present day sustainability thinking, it is perhaps unsurprising that there is a lack of consensus as to what constitutes 'sustainability'. In the words of Mitcham (1995, p. 311): *"Sustainability is one of those ideals which, like love or patriotism, points towards something necessary and even noble, but can also readily become a cliché and be misused by ideologues."*

The challenge of 'defining sustainability' has been attempted by many (Howarth, 1997; Vos, 2007; Basiago, 1995). There have been journal special issues dedicated to the subject of the many meanings of sustainability [Journal of Planning Literature (1995) Vol.9 No.4] and the creation of an accepted definition of the concept [Land Economics (1997), Vol.73, No.4]. However, despite a significant investment of academic enquiry, an all-encompassing definition of sustainability that appeals to all quarters is elusive. Many works recognise that both 'sustainability' and 'sustainable development' are contested concepts (Giddings, Hopwood, & O'Brien, 2002; Hopwood, Mellor, & O'Brien, 2005; Lee K. , 2000; Hansson, 2010). A common theme is differing interpretations of sustainability. Faber, Joma and Van Engelen (2009, p. 337) identify over fifty 'definitions and circumscriptions' of sustainability in their review of the literature.

What is relatively uncontested is that 'sustainability' is a tripartite approach, where 'environmental', 'social' and 'economic' concerns must all be balanced. This is often referred to as the 'triple bottom line' (Elkington, 1997). Even so, there is still scope for different interpretations of what 'environmental, social and economic' sustainability actually means and where the balance is struck.

As Palmer, Cooper & van der Vorst (1997, p. 87) highlight: “*Different groups use the same words to express different ideas; often definitions are coloured by the groups' incompatible core value systems.*” This in turn leads to “*different worldviews, which in turn influence how issues are formulated and actions proposed*” (Giddings, Hopwood, & O'Brien, 2002, p. 187). This is said in as many ways by Voinov & Farley (2007, p. 105) who state that ‘*People tend to define sustainability in the ways that suit their particular applications, goals, priorities, and vested interests*’. They cite the work of Norton (2005), offering the following quote “*...sustainable, used by so many to evoke so much, has been rendered meaningless by the very inclusiveness that makes it a politically useful, large-umbrella characterization of environmentalists' goals and objectives*” (Norton, 2005, p. 47). As Faber, Jorna & Van Engelen (2009, p. 337) highlight “*the confusion surrounding 'sustainability' hinders its implementation*”. In order to make problems manageable and to successfully ‘*construe meaning for different contexts*’ (Vos, 2007, p. 337), it is necessary to focus on certain dimensions of the problem. Voinov & Farley (2007, p. 106) identify a theme running through many constructions of sustainability; “*maintenance, sustenance, or continuity of a certain resource, system, condition, or relationship; in all cases there is the goal of keeping something at a certain level, of avoiding decline*”.

What perhaps is even more interesting is that they go on to propose, looking across a range of natural and man-made social and economic systems, that a ‘sustainable’ state is very uncommon. Drawing on a range of literatures from both the natural and social sciences, Voinov & Farley (2007) suggest that far more common is a ‘cyclical’ phenomenon of creation and destruction. Sustainability, as traditionally interpreted, is an attempt to reach a state of stability that is unusual, perhaps unnatural in many observed systems. Given this as a starting point, they advance that a more useful definition of sustainability is provided by Holling (2000): “*sustainability is the capacity to create, test, and maintain adaptive capability*”, which is suggested as being more helpful because, as long as the system can adapt, it is sustainable. The process of reconfiguration that comes with the renewal of cyclical processes is natural and so systems should strive to maintain the ability to adapt rather than seek to reach a steady state that can be maintained.

The narrative that runs through this thesis is of an industry trying to *adapt* to its changing environment.

### 1.1.1.1 Archetypes of Sustainability

This thesis explores one part of the story of transitioning to a more sustainable automobility paradigm. A transition, by its nature implies the move from one system of doing things to another. It is perhaps easier to know ‘where we are’ and understand the dominant paradigm, than ‘where we will end up’, as the future is yet unknown. There are many visions of what constitutes a sustainable future. Within these projections, there is a spectrum of archetypes of sustainability (Vos, 2007; Sibbet, 2003). ‘Thick’ vs. ‘thin’, ‘hard’ vs. ‘soft’, ‘deep green’ vs. ‘light green’ are all characterisations that can be used to express the poles of a dichotomy. These different archetypes of sustainability translate into a diversity of views about the degree, type and nature of transition that is required. The question of diversity is one that is revisited later in ‘1.1.3.1 The Industrial Ecology of Alternative Vehicles’, page 35.

Table I presents a pen-portrait of these standpoints.

	<b>Dominant paradigm</b>	<b>Thin [Soft] versions</b>	<b>Thick [Hard] versions</b>
<b>Ontology of nature</b>	Nature as raw materials for the human economy.	Some intrinsic values recognized in nature.	Many intrinsic values recognised in nature.
<b>Substitution for natural capital</b>	Infinite substitution.	Some natural capital cannot be substituted.	No declines in natural capital.
<b>Economic growth</b>	No limits.	Win-win relationship emphasised.	Must slow and reverse growth.
<b>Population growth</b>	No limits.	Population growth must be accompanied by per capita offsets.	Must slow growth and achieve declining populations.
<b>Role of technology</b>	Technological rationality.	Cautious scepticism.	Deep scepticism.
<b>Social equity</b>	Left to the market.	Takes connections into account.	Attention to redistribution.
<b>Stakeholder participation.</b>	Decisions by experts.	Collaborative stakeholder processes.	Grassroots democracy.

**Table I - Archetypes of Sustainability reprinted from (Vos, 2007, p. 336)**

Beckerman (1994, p. 191) highlights the dichotomy that “ ‘Strong’ sustainability, overriding all other considerations, is morally unacceptable as well as totally impractical; and ‘weak’ sustainability, in which compensation is made for resources consumed, offers nothing beyond traditional economic welfare maximisation.” Hansson (2010, p. 278) advances the view that both weak and strong notions of sustainability are needed in one and the same analysis - a criterion this thesis tries to meet - noting that this is not a simple task but has the potential to lead to improved policy analysis.



### **1.1.1.2 What do we seek to sustain?**

Fundamental to a conception of 'sustainability' is: *What is it that we seek to sustain?* Thick conceptions of sustainability argue for environmental conservancy, whilst thinner versions of sustainability will advocate the preservation of anthropocentric goals i.e. the delivery of human needs. " *'Politics is the art of the possible'*, [attributed to Otto von Bismarck (1895, p. 248) has since been extended by others with *'rather than the art of the desirable'* ". Through this maxim, consider the standpoints in the sustainability debate: 'Soft' sustainability represents the *'art of the possible'* (from an anthropocentric point of view) whereas 'Hard' sustainability represents the *'art of the desirable'* (ecologically). As Gladwin Kennelly & Krause (1995, p. 878) highlight, the twin filters of *'scientific viability and political usefulness'* constrain management solutions based on the metrics of *'observable fact and humanly assigned value'*. This thesis is rooted in the philosophy of the former for practical reasons. Western lifestyles are dependent on motor vehicles, and the motor industry contributes significantly to Western economies. So fond are Western consumers of the vehicle, that the relationship has been described as a 'love affair' by many authors (Alvord, 2000; Sachs, 1984; Furness, 2010, pp. 6, 222; Lewis & Goldstein, 1983, pp. 24, 34, 90, 105, 121, 131, 138, 141, 182, 245, 292; Merrill & Dalton, 2001). Later in this thesis, the social context is examined (p. 210); here is further evidence that personal mobility is persistent and favoured by social attitudes. Politically, it is hard to conceive of transport options that exclude personal mobility that will be acceptable to the electorate. Employing 175,000 people, and 675,000 people indirectly, (Cooke, 2011, p. 4), the economic contribution of motor industry provides compelling policy reasons for its preservation. The UK automotive industry had a turnover of £49 billion in 2010 (with pre-recession levels of £50 billion) (SMMT, 2013). Of the 1.29 million vehicles produced in the UK in 2010, one million (77.9%) of UK produced vehicles were exported (SMMT, 2013), representing 11% of UK foreign trade in goods (SMMT, 2013, which equates to £29 billion in trade (SMMT, 2013). How can these benefits be retained whilst delivering them in a more sustainable manner? ULEVs, are part of the response but an incomplete one alone, an imperfect solution that favours 'anthropocentric goals'. This thesis will now look at how to reconcile the concepts of sustainability and development, later situating the role of ULEVs as a 'softer' component of a transition to sustainable mobility.

### **1.1.1.3 Sustainable Development**

Sustainable Development is a concept that is closely allied to that of 'sustainability' but with an implicit tension between its two components of 'sustainability' and 'development'. The most widely cited definition is that of the World Commission on Environment & Development, chaired by Gro Harlem Brundtland. It has come to be known as the Brundtland Report.

***“..development that meets the needs of the present without compromising the ability of future generations to meet their needs”***

---

**(World Commission on Environment & Development, 1987, p. 54)**

Daly (1990) & Hansson (2010) state that the role of the Brundtland report in environmental policy in the late 20<sup>th</sup> century cannot be overstated. Proponents of sustainable development argue that conventional economic and development policy ignores environmental consequences, particularly those whose impact is hard to assess in the short-term, and whose effects are only felt in the long term (Beckerman, 1994, p. 192). Chichilnisky (1997) highlights that many authors have asked 'What is Sustainable Development?'; indeed, there is as much divergence and breadth of opinion as to what constitutes sustainable development as there is 'sustainability'. This leads to much criticism of sustainable development as a concept (Giddings, Hopwood, & O'Brien, 2002, p. 188). One statement is that *'sustainable development [...] sounds so good everyone can agree with it whatever their own interpretation [but] this can be seen as a strength'*; another states that *"the blandness of meaning makes the concept almost meaningless and it lacks any clear rigour of analysis of theoretical framework"*. This view is also expanded upon in earlier work by Beckerman (1994, pp. 192-193) who advances that *'...it must be more than just an expression of social values or political preferences disguised in scientific language. Ideally it should be defined so that one could specify a set of measurable criteria such that individuals and groups 'with widely differing values, political preferences, or assumptions about human nature could agree whether the criteria are being met in a concrete development program.'*

In trying to understand 'sustainable development's' shortcomings as a concept, Lee (2000, p. 32) cautions that the concept of sustainable development is often advanced without due references to its *'intellectual and historical roots'*. He challenges anthropocentric views of sustainable development as

“internally inconsistent”. This leads Lee (2000, p. 40) to the conclusion that ‘sustainable development is eco-socially sustainable development’ and this in turn is predicated on a platform of ecological sustainability, but exclusive from it as a concept. Hansson (2010, p. 276) argues in this vein that “the concept of ‘natural resources’ is a technological concept [...] since a natural object is a natural resource only to the extent that we have some technology with which we can make use of it” and that the value of these resources, when conceived as such, are fundamentally anthropocentric since they depend on human needs. By contrast, conceiving them as “ecological assets” is non-anthropocentric, as its value is in existing independent of humanity.

Even if a ‘perfect’ definition of sustainable development could be conceived of that appeals to all quarters, it is important to ground the debate in more practical realities. This is very much an ‘applied’ study, a piece of ‘engaged scholarship’ (See page 192) and therefore it seeks to understand sustainable development in a way that can be applied operationally. Daly (1990) advances the idea that to operationalise sustainable development, it is important to differentiate between growth and development, putting forward the following definitions: “To grow means to increase naturally in size by the addition of material through assimilation or accretion. To develop means to expand or realize the potentialities of; bring gradually to a fuller, greater, or better state.”

Speaking about Industrial Ecology (see p. 30), den Hond (2000, p. 60) says that sustainable development “finds its legitimation in the question of what the environmental impact would be if, within a period of several decades and with a growing world population, each individual person enjoys, ideally, a standard of living common to the Western industrialised countries during the 1990’s.” In the field of automobility, one notable attempt by Sperling & Gordon (2010, pp. 1-2) asks ‘Can the planet sustain 2 billion cars by 2020?’, with growth from the current figure of over one billion; their brief answer is ‘not as we know them’. Perhaps the implication of this is that the vehicle industry and the business models that it employs will also be ‘not as we know them’. In order to understand why, a framework for understanding and reconciling available resources with impact is required, which considers growth in population, affluence and consumption. This will be covered in the next five sections.

#### 1.1.1.4 Strategising for Sustainable Development

***“The concept of sustainable development does imply limits – not absolute limits but limitations imposed by the present state of technology and social organisation on environmental resources and by the ability of the biosphere to absorb the effects of human activities.”***

(Brundtland, 1987, p. 27)

There is a need to translate an understanding of the principles of sustainable development into strategies for practical action. The resource funnel (See Figure 1) is used in processes for sustainable change management, like ‘The Natural Step’ (n.d.). It presents the concept of sustainable development (See p. 17) in the format of a visual metaphor. Visual metaphors have been used as a useful tool to help explain complex problems. This captures the nature of environmental limits and constraints as expressed through documents such as the Brundtland Report, in a simple way clearly illustrating the temporal dimension of the problem. What it communicates clearly is that, as a result of growing demand, and a consumption of resources which decreases availability, the available solution space decreases over time. The longer society takes to address problems, the more challenging the solutions become, as a result of the lesser margin for action imposed by greater constraints. The rate at which the funnel narrows is not fixed, but a function of the availability of resources and the demand that is put on those resources. In taking Hansson’s (2010, p. 210) view of considering both weak and strong interpretations of sustainability, it is important to consider the degree to which less radical change now constrains future decisions.

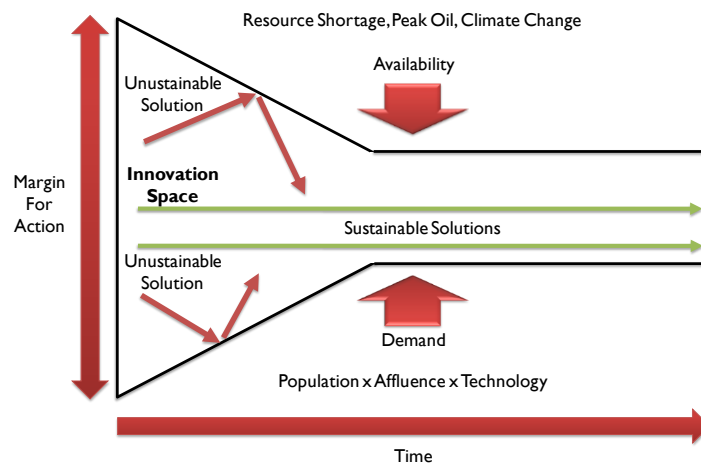
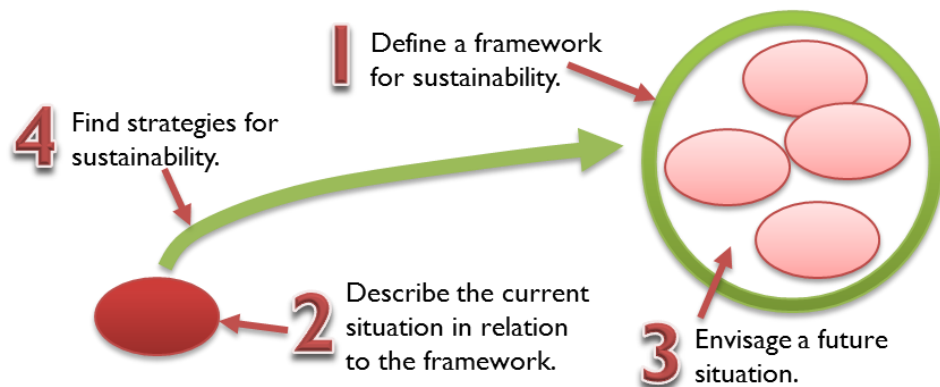


Figure 1 - The Resource Funnel – Adapted from (Nattrass & Altomare, 1999, p. 19)

“As the funnel narrows there are fewer options and less room to manoeuvre. Organisations that continue business-as-usual; are likely to hit the walls of the funnel, and fail.” (The Natural Step, n.d.) Development of more sustainable innovations and practices broaden the scope of society’s possibilities by “widening” the funnel (The Natural Step, n.d.). Another component of frameworks, such as The Natural Step, is ‘backcasting’ (Holmberg, 1998, p. 63; Ny, MacDonald, Broman, Yamamoto, & Robért, 2006), which helps to establish the link between ‘sustainability science’, an understanding of the problem, and the practical measures that are needed to address the problem. (Ny, MacDonald, Broman, Yamamoto, & Robért, 2006). The process is presented in Figure 2.



**Figure 2 - The Steps in Strategic Planning for Sustainability Redrawn from: (Holmberg, 1998, p. 32)**

In the context of motor vehicles, the two main constraints (Nieuwenhuis P. , 2012, p. 17) are the ability of the environment to absorb CO<sub>2</sub> and increasing resource scarcity, with oil being of primary concern. As such, frameworks for sustainability for the vehicle industry have tended to focus on either fuel consumption or carbon emissions targets (Nieuwenhuis & Wells, 1998); the two are intimately linked so improvements in one have corollary benefits for the other. Later, this thesis looks at the present state of the vehicle industry in relation to frameworks for sustainability and looks at what this means for the future of mobility. The transitions framework gives insight into what the ‘strategies for sustainability’ might look like, moving from the current to future situation.

### 1.1.1.5 The Environmental Footprint of Motor Vehicles

Lifecycle analysis (LCA) is a tool which is deployed to understand the impact of products on the environment, through manufacturing, use and disposal (MacClean & Lave, 1998). Socio-ecological impact matrixes are a qualitative tool which can be used to interpret the impacts of a product from ‘cradle to grave’ (Belz & Peattie, 2009, p. 58). Table 2 sets out the impacts of motor vehicles over their lifecycle. Belz & Peattie (2009, p. 58) note that 80% of a vehicle’s energy consumption and emissions occurs during use.

	<i>Extraction of Raw materials / Material manufacturing</i>	<i>Automobile Manufacturing</i>	<i>Automobile Use / Maintenance</i>	<i>Automobile Disposal</i>	<b>Legend</b>
<i>Resource Use</i>	High Impact	Low Impact	Low Impact	Low Impact	High Impact
<i>Energy Consumption</i>	Medium Impact	Medium Impact	High Impact	Low Impact	
<i>Air</i>	Medium Impact	Medium Impact	High Impact	Low Impact	
<i>Noise</i>	Low Impact	Low Impact	High Impact	Low Impact	Medium Impact
<i>Water</i>	High Impact	Medium Impact	Low Impact	Low Impact	Low Impact
<i>Waste</i>	Medium Impact	Low Impact	Low Impact	High Impact	
<i>Land Use</i>	Low Impact	Low Impact	High Impact	Low Impact	Low Impact
<i>Health Accidents</i>	Low Impact	Low Impact	High Impact	Low Impact	

**Table 2 - A Socio-Ecological Impact Matrix of the Environmental Impacts of Motor Vehicles**  
Redrawn from (Belz & Peattie, 2009, p. 64) citing (Belz, 2001, p. 175)

Another method of quantifying the environmental impacts of motor vehicles is to adopt the perspective of ecological footprinting (Rees W. E., 1992; Wackernagel, 1994). Ecological footprinting equates the environmental impact of a given lifestyle with a corresponding area of land. The land represents how much land would be required to support, not only the resources consumed, but also the biological capacity required to carry the impacts of the consumption (Zhang, 2005, p. 5). An equitable distribution reflects the total of the world’s productive land, divided by the global population (Zhang, 2005, p. 6); this figure is somewhere between 1-3-1-5ha. With population growth, this figure will diminish to 1.0ha by 2050 (Zhang, 2005, p. 17). Zhang (2005, p. 1), notes that the average U.S. car owner, taking the example of a generic American ‘sedan’, expends 0.6ha of their ecological budget on their vehicles alone (equating to roughly 50%). According to Zhang (2005, p. 1) this figure can range from 30% to 100% based on vehicle efficiencies of 55mpg to 12mpg respectively. The environmental impact of a motor vehicle is 800 times the area that it physically occupies (Zhang, 2005, p. 1). This sets out the impact of conventional vehicles, but what about the alternatives?

Returning to the concept of Life Cycle Assessment, a comprehensive study has been done by Hawkins, Singh, Majeau-Bettez, Strømman (2013) comparing a range of ULEV technologies to conventional ICE vehicles. Across all types of vehicles, the environmental indicators - 'human toxicity potential', 'mineral depletion potential' and 'freshwater eco-toxicity potential' - are high in the production phase. All indicators are higher during production for EVs which have a substantially greater environmental impact in production in all categories, except for 'terrestrial acidification potential' (Hawkins, Singh, Majeau-Bettez, & Strømman, 2013, p. 61). The main improvement ULEVs offer are in the reduction of 'global warming potential' and 'terrestrial acidification potential' in use (depending on the source of the electricity). It is this lower emissions in use which offsets the energy in production. When powered by electricity with EU average CO<sub>2</sub> emissions, there is a 20-24% reduction vs. petrol vehicles and a more modest 10-15% reduction against diesel vehicles. However, considering the whole lifecycle, EV technologies can actually end up producing more CO<sub>2</sub> if used with electricity from coal. An earlier LCA on Hydrogen vehicles by Zamel & Li (2006) examined a range of different pathways and reached similar conclusions that only H<sub>2</sub> from coal had greater GHG intensity than the other methods of H<sub>2</sub> production; however other hydrogen pathways offered lower life-cycle energy consumption and carbon emissions. It is important to situate these 'gains' in a broader picture of other environmental impacts arising from ULEV production. ULEV vehicle technologies are in their infancy and, as such, the present state-of-the-art is not necessarily indicative of the ultimate environmental potential of the technology (Hawkins, Singh, Majeau-Bettez, & Strømman, 2013, pp. 58-59).

There are corollary impacts to this. Hawkins, Singh, Majeau-Bettez, Strømman (2013) note that as a result of the greater impact and toxics burden of ULEVs, more emphasis should be put on Life Cycle Management of the materials used in EVs. Ideas such as "closed loop recycling" [sometimes referred to as cradle-to-cradle approaches (Braungart & McDonough, 2002)] combined with industrial ecology initiatives (p.32) help to ensure that these toxics stay within a circular supply chain and do not enter the environment as waste. Furthermore, approaches such as 'product durability' ensure that wise use of resources is made, extending vehicle lifecycles and making best use of energy invested in manufacture. However, the greatest challenge remains: reducing vehicles' impact in use.

### ***1.1.1.6 Resource Scarcity & Peak Oil***

The last section examined the impacts of motor vehicles over their life cycle. Noting most impact occurs in use, the most pressing resource constraint affecting the current automobility paradigm is that of the availability of oil. Nieuwenhuis (2012, p. 17) [citing (Kendall, 2008; Dennis & Urry, 2009)] highlights that transportation is 95% dependent on oil, and that half of all oil consumed worldwide is used to provide transportation services.

The American oil geologist Marion King Hubbert developed his hypothesis of “Peak Oil” (Hubbert, 1956, pp. 22-27) [for a more contemporary account of developments to the theory since, see (Campbell, 2004)]. His conjecture is that extraction of any natural resource, of which there is a finite amount, follows a curve. Peak oil, is the apogee of petroleum extraction, the top of a bell-shaped curve. Once this point has been crossed, oil production can only enter terminal decline.

Nieuwenhuis (2012, p. 31) observes that, whilst the supply of oil is estimated to peak globally somewhere in the period 2010-2015, the demand for oil is set to increase as newly motorising nations develop. There are many proponents of alternative fossil fuel extraction and processing technologies (de Castro, Miguel, & Mediavilla, 2009) that have the potential to extend the life of fossil fuel based vehicle technologies but come with significant environmental penalties (Strahan, 2009). The technology is available but not necessarily desirable, as it would further perpetuate dependence on finite and carbon-intensive sources of energy. There is an extensive literature (Heinberg, 2006; England, 1994; Ayers & Ayers, 2010) addressing the need to urgently reduce consumption of fossil fuels.

Equally, questions have been raised about potential resource conflicts that could arise out of a change of technological trajectory and shift to ULEVs. “Peak lithium” has been raised as one scenario arising as a result of a rush to Lithium Ion battery technology (Cheng, 2008; Johnson K., 2009); Miedema & Moll (2013) consider this more recently with specific regard to the EU27. Wadia, Albertus & Srinivasan (2011) consider a range of alternatives to platinum. Råde (2001) examines a range of scarce metals and potential resource constraints should fuel cells be adopted in much greater numbers. The scenario of ‘peak platinum’ is considered by (Lifton, 2007).



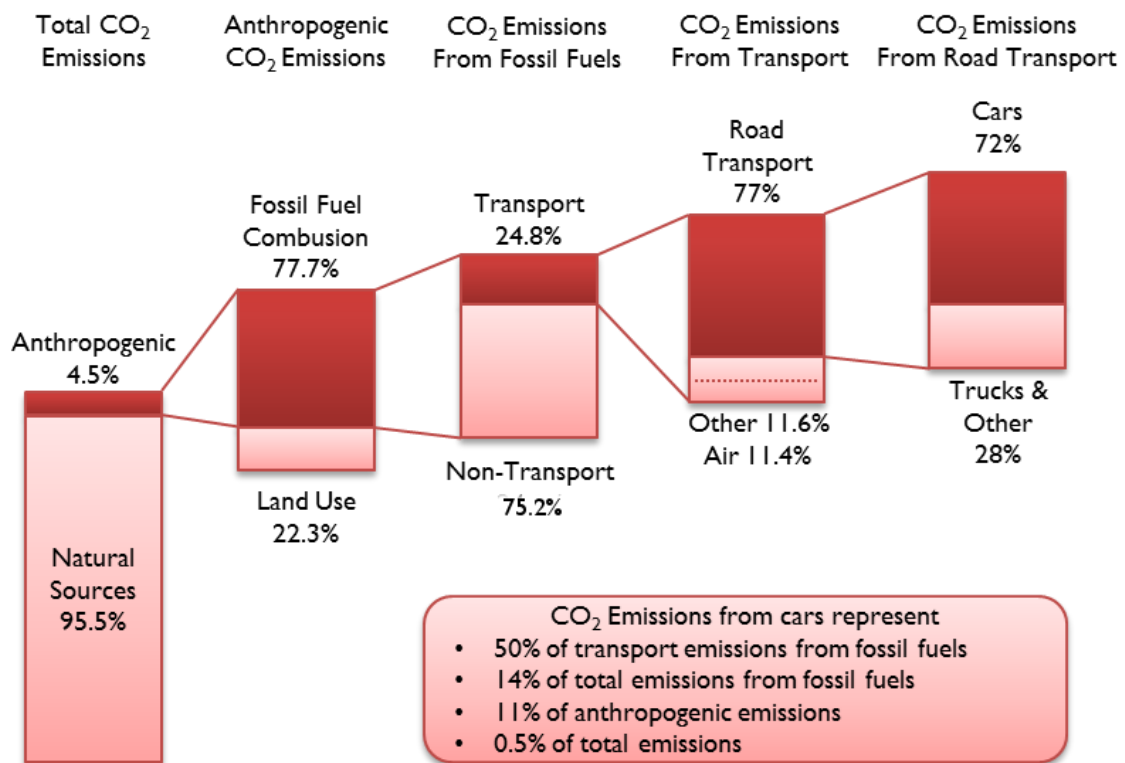
### ***1.1.1.7 Climate Change & Automobility***

Increases in atmospheric concentrations of CO<sub>2</sub> and other GHGs are causing a global rise in temperatures. These increases are driven by anthropogenic sources, which are increasing concentrations of GHGs faster than natural sinks are able to absorb them (Hansen, Sato, Ruedy, Lo, Lea, & Medina-Elizade, 2006). Whilst anthropogenic CO<sub>2</sub> emissions are small compared to natural emissions, they have the potential to change and disrupt processes that are finely balanced. What makes understanding climate change so particularly challenging, is the climate's non-linear and "complex" response to changing carbon dioxide levels (Dijkstra, 2013).

John Cook, from the University of Queensland has likened the global rate of climate warming to '4 Hiroshima bomb detonations per second' over the past several decades (Australian Associated Press, 2013). Whilst it is convenient to look at the global effect of GHGs on global temperature, this masks the fact that the effects of climate change vary tremendously in their local impact. The potentially catastrophic impacts of a range of temperature rises has been summarised in the IPCC's fourth assessment report (IPCC, 2007).

In order to avoid some of the worst impacts of climate change, there is a global need to curb GHG emissions and seek a stabilisation of global GHG levels. The UN's chief climate scientist, who heads the IPCC, Rajendra Pachauri has called for a reduction in atmospheric carbon dioxide concentrations to 350ppm (Mc Kibben, 2009). The IPCC's last report in 2007 called for a target of 450ppm.

Later in this chapter, (page 26) an approach by Tukker, Eder & Suh (2006, p. 184) to managing consumption is outlined, which focuses on addressing the areas of consumption with the largest share of impact as a viable and manageable strategy. Focusing narrowly on emissions, the graph overleaf demonstrates transport is of significant concern; and within transport, road transport and cars comprise the greatest proportion of carbon emissions. It helps to contextualise the role of motor vehicles in the climate change debate.

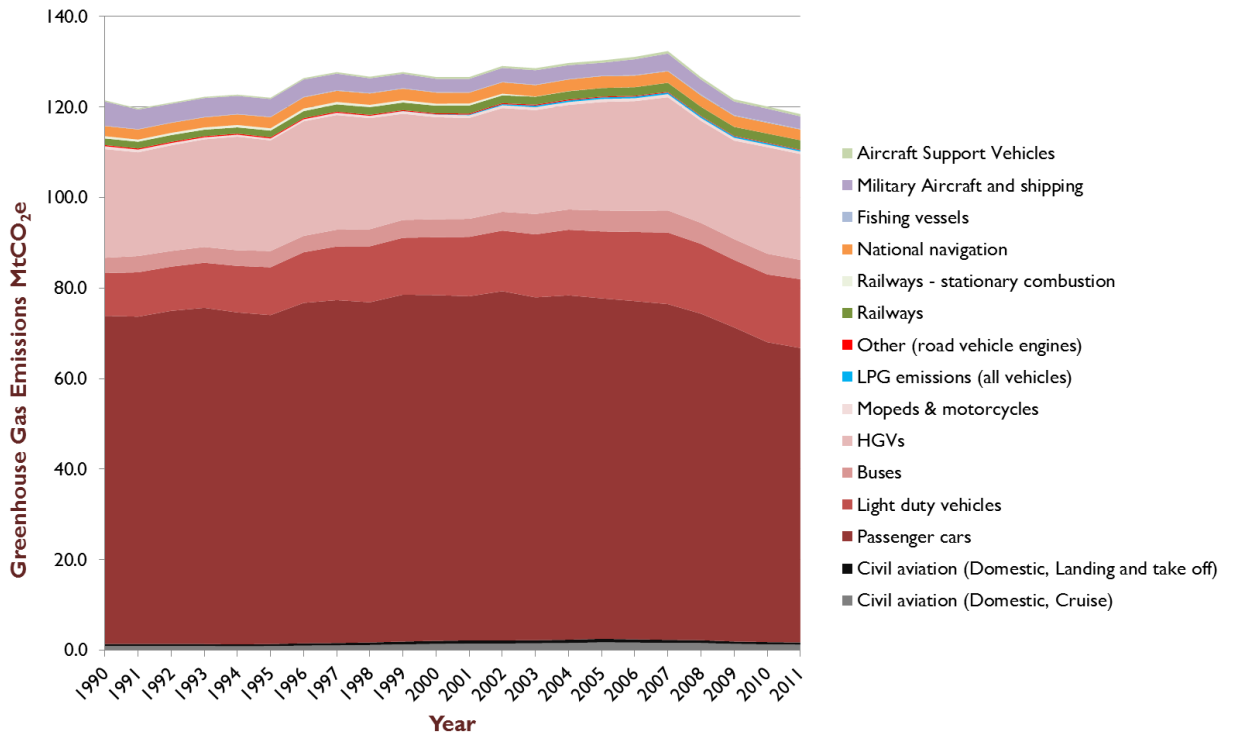


**Figure 3 - Contextualising Vehicle Emissions redrawn from Bosch (Bosch, 2010)**

Figure 3 provides a useful illustration of how CO<sub>2</sub> emissions from vehicles in the context of other emissions can be considered. In 2010, transport accounted for 22% of global CO<sub>2</sub> emissions (International Energy Agency (IEA), 2012, p. 10) [note this figure differs from the one quoted in Figure 3 quoted from a different, older source], the second largest sector after electricity and heat. The IEA note that (with a contributory factor being dramatically cheaper fuel in the US, compared to the EU), there is variation in the average fuel economy and hence GHG emissions of light duty vehicles of 50% across OECD countries. Transport CO<sub>2</sub> emissions are projected to grow with increased fuel use by 40% by 2035.

In the UK context, the Climate Change Act (2008) sets legally binding targets to cut UK carbon emissions by at least 80% (from the 1990 baseline) by 2050. This thesis will now examine some of the specifics of CO<sub>2</sub> emissions in the UK context with specific reference to transport and motor vehicles.

Across all GHG emissions, (normalised to MtCO<sub>2</sub>e) transport accounts for 21.5% of all UK GHG emissions in 2011. Focusing on carbon emissions exclusively, this figure rises to 25.9% (Department of Energy and Climate Change, 2013, p. 5). Examining the figures for GHG emissions from the transport sector (See Figure 4), it can be seen how road based transport and automobility dominates these figures.



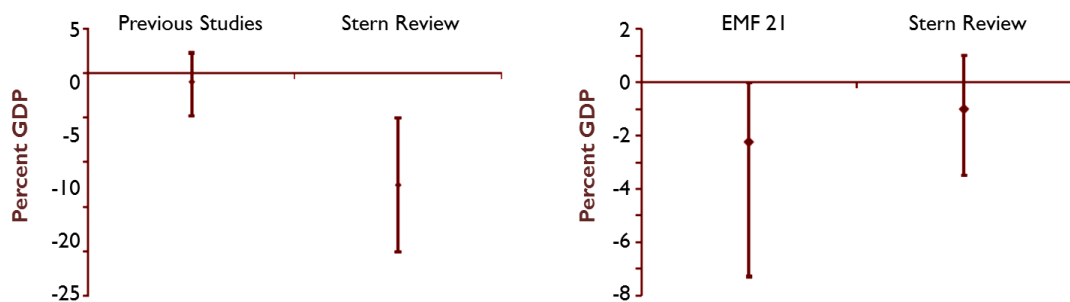
**Figure 4 - UK Transport GHG Emissions 1990-2011**  
 Compiled from (Department of Energy and Climate Change, 2013)

Looking at the general trend of GHG emissions from transport, it is shown they have continued to rise, albeit slowly, in the period 1990-2007. Recently, the global double dip recession has caused a general slowdown in economic activity which has resulted in a temporary decrease in carbon emissions.

The Stern Review (Stern, 2006) marked a significant turning point in the UK climate debate. Whilst it is not the first report that places climate change within an economic framework, it is significant for the scale of attention that it received.

### 1.1.1.8 Stern's Framing of Climate Change

Stern (2006) depicts climate change as the biggest market failure ever seen, and presents climate change as a challenge for economics. What is also significant is that in analysing previous studies, Stern concluded that the costs of the damage that climate change will cause to global economies had been dramatically underestimated, whilst the costs of emissions reduction to avoid climate change had been over-estimated. This is illustrated in Figure 5.



**Figure 5 - Left: Estimates of the damage costs of climate change, Right: Estimates of the costs of emission reduction, Comparing the Stern Review with previous studies**  
Redrawn from Tol & Yohe (2006, pp. Figure 1, p.235)

Whitmarsh & Köhler (2010, p. 427) identify that many of the strategies that address GHG emissions from vehicles have corollary benefits in addressing other areas of the unsustainability of vehicles. Nieuwenhuis (2012, p. 20) notes that, whilst the car industry has made 'clear efforts' to reduce CO<sub>2</sub> emissions, it 'has failed to grasp the magnitude and urgency of the task'. Here, it is also worth stating the obvious that, in addition to their effect on the environment, emissions of pollutants from vehicles exhausts are detrimental to human health (Elzen, Geels, Hoffman, & Green, 2002, p. 2).

It is important to distinguish, that whilst vehicle emissions have a global impact, it is often in those places where the *local impact* of vehicle emissions is felt acutely that legislation against emissions has been particularly progressive (with the caveat that the society has the financial resources to permit a progressive approach to environmental control). The policy levers that have been used globally to challenge automakers to reduce their vehicle emissions will be examined in more detail. Appraising the need to change industry practices requires a quantitative approach to understand industry impacts. This is explored overleaf.

### ***1.1.1.9 Accounting for Development***

The IPAT equation (shown in Equation 1) is one early theory that has been advanced to explain how impact on the environment results from the interplay of three forcing factors: Population, Affluence and Technology.

$$I = P \times A \times T$$

Where:

I	=	Impact on the Environment
P	=	Population
A	=	Affluence
T	=	Technology

**Equation 1 - IPAT Equation**

Chertow (2001, p. 1) discusses the evolution of the equation from its roots in a dialogue between Ehrlich & Holdren (1971; 1972) and Commoner (1972; 1972). Through taking a retrospective view on thirty years of debate and evolution of this concept, Chertow (2001) characterises the way in which the discipline of 'Industrial Ecology' has shaped the debate surrounding the inter-relationship of the IPAT variables.

$$I_m = P \times A \times C \times T$$

Where:

$I_m$	=	Impact
P	=	Population
A	=	Affluence (per capita GDP)
C	=	Consumption [Intensity of Use] (per unit of GDP)
T	=	Efficiency of technology [Ratio of Environmental Impact : Unit of Goods Demanded] (per unit of GDP)

**Equation 2 - ImPACT Equation (Waggoner & Ausubel, 2002)**

Waggoner & Ausubel (2002, p. 7860) describe their "renovation" of the IPAT identity, with one of their more interesting contributions being the way in which they have taken the 'T' term (technology), and disaggregated it into two distinct components (C & T) (See Equation 2). This is significant, as it recognises the discourse of consumption (which is returned to later on page 26) as explicit, distinct and decoupled directly from technological capability.

Furthermore, they equate these different 'forcing impacts' with actors so "*parents modify P, workers modify A, consumers modify C, and producers modify T*". What is significant about the development of IPAT into ImPACT, is that it now explicitly recognises consumption behaviours as being a mediating factor for environmental impact.

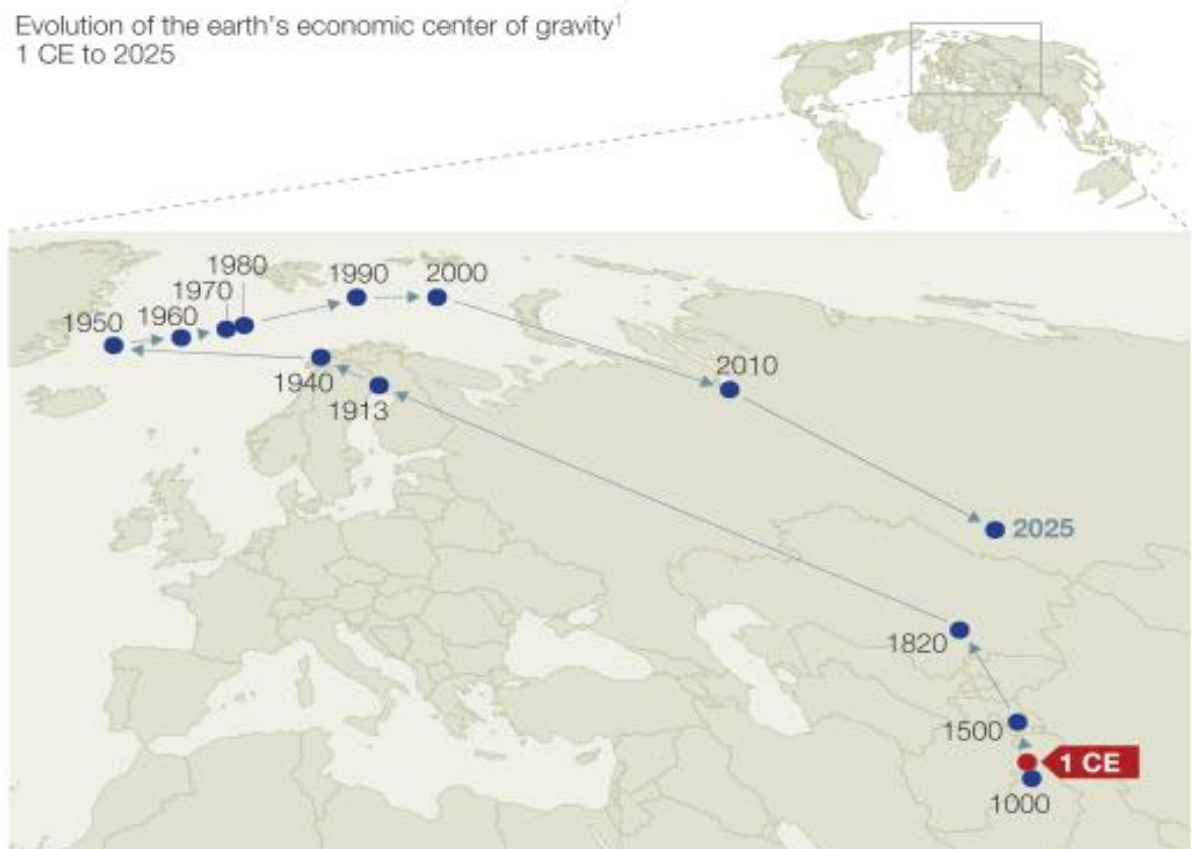
One of the prominent foci of this thesis is how new business models aid the 'transition' to a mobility regime that features innovative ULEV technologies; in other words, the measures that lead to a decline in the 'T' forcing factor [efficiency] (Waggoner & Ausubel, 2002, p. 7861). This could be by effecting change to **KEY ACTIVITIES** to reduce the impact of the vehicle in manufacture or by changing the environmental **VALUE PROPOSITION**, in relation to the products' environmental performance. What may appear less explicitly, but is of equal relevance, is how newer business models can lead to changes in consumption practices, leading to an improvement of the forcing factor [C]. This may be by changes to the **CUSTOMER RELATIONSHIP**, or even through re-envisioning the whole conception of the vehicle **VALUE PROPOSITION**.

However, York, Rosa & Dietz (2003, p. 363) contest that the relationship between affluence and environmental impact is more ambiguous. In using a stochastic variant of the IPAT model which allows for hypothesis testing, they analysed a range of nations, looking at both their energy footprint and emissions of carbon dioxide. They found that CO<sub>2</sub> emissions increased with affluence but '*at a declining pace*' (York, Rosa, & Dietz, 2003, p. 363). What was more significant is that the **energy footprint** increased with affluence '*at an escalating pace*'. The reason being that the more affluent societies have access to cleaner technologies by virtue of their wealth, but this comes at a trade-off, as '*de-carbonization appears to come at the cost of increases in other types of impact*' citing nuclear power and the environmental destruction that arises from large-scale hydropower installations as examples.

In order to the understanding of factors, 'C' and 'T' there is a need to contextualise them, by providing a brief pen portrait of factors 'P' and 'A'. This is also useful in situating the UK context of the study.

### ***1.1.1.10 Population, Development & The International Context***

Population growth is one of the drivers of greater resource consumption and hence greater CO<sub>2</sub> emissions and energy footprint (York, Rosa, & Dietz, 2003, p. 363). The global population is expected to continue to increase from a present estimate of 7.13 billion, with long range predictions believing them to peak at a figure of around 9.22 billion by 2075 (United Nations, 2004, p. 1). This is accompanied by a rise in average life expectancy, (United Nations, 2004, p. 2). Alongside this general growth in global population, there are also profound shifts in the global economy, with changing patterns of wealth distribution, prosperity and affluence. A 'McKinsey & Co.' report by Dobbs et.al. (2012, p. 17) plots (see Figure 6) the worlds shifting economic centre of gravity over the past 2000 years. They note that by far, the most profound change occurred between the years 2000 and 2010.



**Figure 6 - The Worlds Shifting Economic Centre of Gravity**

**Graphic Legend Reads:** “Economic centre of gravity is calculated by weighting locations by GDP in three dimensions and projected to the nearest point on the earth’s surface. The surface projection of the centre of gravity shifts north over the course of the century, reflecting the fact that in three-dimensional space, America and Asia are not only ‘next’ to each other, but also ‘across’ from each other. Data Source: McKinsey Global Institute analysis using data from Angus Maddison; University of Gronigen. (Dobbs, Remes, Manyika, Roxburgh, Smit, & Schaer, 2012, p. 17)”

Moore, Staley & Poole (2010, pp. 566-567) observe that, whilst presently the US and Europe are responsible for the largest overall GHG emissions, in the future, the pressure will come from nations such as China, India, Brazil and even Africa where, the 'economic elite' seek to mirror the consumption behaviours of industrialised countries (Fuchs & Lorek, 2002, p. 21). They note that China exceeded US carbon emissions for the first time in 2006 and is expected to produce 29% of global GHG's by 2030 (Moore, Staley, & Poole, 2010, p. 567). They note that, regardless of what the US and wealthier nations of Europe can achieve in terms of reductions in GHGs, future emissions will largely be determined by those countries that are developing rapidly. This rapid growth and development is accompanied by a number of other trends, which have the potential to radically shape transport policies. Notably, explosive growth and development has been accompanied by a wave of urbanisation (Dobbs, Remes, Manyika, Roxburgh, Smit, & Schaer, 2012). By 2008, it was estimated that globally a greater proportion of the population was living in towns, rather than cities (United Nations, 2007). Mitchell, Borroni-Bird & Burns (2010, pp. 52-83, 156-187) have examined how the vehicle industry needs to respond to the problems and challenges these megatrends present. Within these global changes, there are questions of fairness but also of how countries and blocs position themselves in relation to international climate negotiations.

There are many works that address the question of equity in global decarbonisation strategies (e.g. Sachs, 2005; Edenhofer, Carraro, & Hourcade, 2012; Miketa & Schrattenholzer, 2006; Chakravarty, Chikkaturb, de Coninck, Pacalaa, Socolowa, & Tavonia, 2009). For policy makers in the highly developed world, there is a delicate political balance to be struck between decarbonisation on the one hand and maintaining stability in their economic systems, (Kaivo-oja, Luukkanen, & Jyrki, 2004) especially in the face of relentless competition from emerging economies. Here there is a balancing act between providing leadership internationally whilst not undermining national prosperity. This can be summed up by the phrase 'Global Commons: Domestic Decisions', with the issues being discussed in an edited book of the same name by Harrison & Sundstrom (2010).



### ***1.1.1.1 Sustainable Mobility: A Wicked Problem?***

The challenges presented exhibit a great deal of complexity. The term ‘wicked problem’ was first used by Churchman (1967) to describe such intractable challenges. Rittel & Webber (1973, p. 156) note that conventional science has evolved to deal with “tame” problems. They define ‘wicked’ problems with a number of specific criteria (1973, p. 161), making the case that wicked problems have ‘*no definitive formula*’, only different approaches to the problem. Also there is no ‘*stopping rule*’, in that there is not definitive way of knowing when the problem has been solved (1973, p. 162). This thesis has already explored that there are multiple, contested conceptions of sustainability and the concept is applied to problems in multiple ways (p. 4-5). This resonates with one of the features of wicked problems, (1973, p. 162) in that they cannot result in a ‘*true*’ or ‘*false*’ answer, but instead viewed from the perspectives of many individuals as only ‘good’ and ‘bad’ solutions (1973, p. 163). Furthermore, it is impossible to know immediately whether the solution to a wicked problem is good, or whether there are waves of unintended consequence (1973, p. 163). A brief cautionary example in the sustainable mobility arena might be the many environmental and social consequences of a dash to biofuels (Starbuck & Harper, 2008, pp. 199-205). This example also demonstrates another aspect of ‘wicked problems’ (1973, p. 163) that ‘*every solution [...] is a one-shot operation*’ and ‘*every implemented solution is consequential*’ – “*there is no opportunity to learn by trial-and-error*”. There is no clear set of rules about how to approach wicked problems; no list of what approaches to solve the solution are and are not permissible (1973, p. 164). Essentially, every wicked problem is one-of-a-kind and individual (1973, p. 164), and indeed wicked problems are often symptomatic of other problems (1973, p. 165). The way in which wicked problems are defined in many ways defines their solutions (1973, p. 166). Furthermore, those engaging with wicked problems have no ‘*right to be wrong*’ (Rittel & Webber, 1973, pp. 166-167) as attempted solutions to wicked problems have real world implications. Many other authors have approached the definition of wicked problems since Conklin (2008). Another term which could apply to these ‘wicked’ problems with a social dimension is that of the ‘social mess’. Ackoff (1974) applies this term to interconnected social problems, and triumphs the use of systems methodologies to understand and intervene in such complexity.

### ***1.1.1.12 A Systems View of Sustainability & Automobility***

'Systems thinking' is a tool that has been applied to wicked and messy problems; for example, to challenges of business and management (Jackson, 2003; Mingers & White, 2010), innovation (Galanakis, 2006), the problem of sustainability and sustainable development (Gallopín, 2003; Clayton & Radcliffe, 1996; Fullan, 2004; Ison, 2010) and also to planning issues, such as those encountered in transportation (Kane & Del Mistro, 2003) and other issues allied with mobility, such as safety (Salmon, Stanton, & McClure, 2012). Systems thinking involves a move away from linear ways of addressing problems, and a move towards examining the 'web' of issues that are manifest in 'wicked' problems. As a tool and perspective on a problem, it is helpful as it allows for multiple world views [*Weltanschauungen* (Checkland, 1981)]; furthermore, it is a perspective that takes into account the multi-faceted nature of complex problems. To some degree, this perspective helps as this thesis attempts to develop ideas that require a resolution of some of the challenges of multiple definitions of sustainability (p.4).

What sort of systems, perspectives and theory can find application in unpicking such messy problems? Pidd (2003, p. 113) notes how Checkland (1981) contrasts 'soft systems' to the then dominant approach to systems - 'hard systems'. From this, a group at Lancaster University, developed the notion of 'soft systems', along with its accompanying soft systems methodology (SSM). Perhaps two of the defining characteristics of soft systems approaches are that they were developed to deal with more complex, less clearly structured problems and as such were designed by Checkland (1981) to be more useful for business. This marked a turning point in the literature. Whilst this thesis does not explicitly use SSM to address the problem, the two frameworks used to interrogate the problem 'transitions theory' [p.48] (Geels F. W., 2002) and 'business model ontology' [p.90] (Osterwalder & Pigneur, 2002) both have embedded systems, techniques and understanding at their heart. There is also evidence of systems thinking in allied fields of literature that, although not examined directly in this study, are part of the 'constellation' of literature that has informed the approaches such as 'transitions theory' and the 'business model ontology' that have been adopted in this work.

So useful is 'systems thinking' to the field of 'innovation' that a whole literature has grown up around the intersection of the two disciplines; the field of 'Innovation systems'. Lundvall (1985) recognises that, as a process, innovation requires a web of collaborating actors and stakeholders. 'Innovation' does not take place within a single entity, such as a firm, but results more from a complex series of interactions (Lundvall, 1985, p. 29). Often studies of innovation systems are bounded by spatial criteria (local, regional, or national); in this study the UK context is examined, and so, effectively this study is one of a single sector, one facet of what Freeman (1995) would describe as a "National Innovation System". Another important intersection where systems thinking has informed a whole new field of literature is that of socio-technical systems (STS), a term introduced by Trist & Bamforth (1951)]. STS is a field that recognises, in many domains of application, a complex interaction between 'people' [society], and 'technology'. According to Geels (2011, p. 30) STS provides a systems basis, (along with evolutionary economics) for the multi-level perspective MLP on which much of transitions theory rests.

The 'transitions' framework recognises the need for 'system innovation' and addresses issues of how a given system of interest (in this case the automobility system) can shift from one technology state to another. It recognises the interconnected nature of different actors and how, in the context of automobility, a large scale system reconfiguration will introduce new actors and stakeholders not already part of that system (Geels, Dudley, & Kemp, 2012, p. 358). Central to this concept is the idea of interconnected issues and a move away from simple causality to more nuanced systemic ways of understanding problems (Geels 2011, p. 29) [explored later on p. 62].

One of the themes that runs through systems theories is questions of hierarchy, in other words, examining systems on different levels. Transitions theory presents a multi-level framework. Thinking of the theory used to interpret the cases in these terms, if the 'transitions' theory provides a framework at the 'macro' level that helps to interpret the wider 'process' of what is happening, then the 'Business Model' is a way of interrogating on a 'micro' level the system dynamics within the firm.

Central to the transitions theory is the concept of the 'regime' (p.56), which represents the dominant practices and actors within the system under transition. Urry (2004, pp. 25-26) advances six distinct elements that comprise the 'specific character of domination' of the current automobility system:

- 1 The "Manufactured Object", the industry that is engaged in its production, and the specific cultures and practises that industry has begotten.
- 2 "Individual Consumption" and the degree to which the car, as an artefact, confers on its owners 'sign-values'
- 3 The 'Complex' web of interconnection between actors that support the present automobility paradigm, petrochemical manufacturers, supply chains,
- 4 The 'quasi-private form of mobility' that favours ownership of the car as a personal object, and its favoured dominance over public transport.
- 5 'Dominant Culture' of what constitutes a good life and standard of living.
- 6 'Environmental Resource Use' that results

Many elements of this character of domination are captured by the business model used to make vehicles. The **VALUE PROPOSITION** of the 'manufactured object' arises from the **KEY RESOURCES** used to create the vehicle and the **KEY PROCESSES** of manufacture. *Individual consumption* by different **CUSTOMER SEGMENTS**, whilst also a function of society and culture, is mediated by the customer relationships VMs have with individuals. The 'complex web of interconnection' is captured in part by the **KEY PARTNERS** that support the present regime. Furthermore the **COST STRUCTURE** of the industry combined with the degree to which environmental and social costs are externalised by current regulation helps cement the car as central to the last three factors. Hence, understanding of 'Business Models' is a way of systematically understanding the logic that allows firms to create and deliver value. Indeed, whilst presenting them in a different format, the visual diagrammatic methodology and "boundary" to the firm shares similarities with the 'activity models' of soft systems methods for understanding a system. Zott & Amit (2010, p. 216) also lend a degree of credibility to the idea of viewing a "business model" as a system "The firm's business model is a system of interdependent activities that transcends the focal firm and spans its boundaries. The activity system enables the firm, in concert with its partners, to create value and also to appropriate a share of that value.". The business model is an 'activity model' (Checkland & Scholes, 1999, p. A21) of this 'activity system' (Zott & Amit, 2010, p. 216). As Checkland & Scholes (1999, p. A21) expand, "purposeful activity models [...] are devices – intellectual devices, to structure an exploration of the problem situation being addressed".

Across many fields of enquiry into sustainable development there is an enduring argument about how quick the pace of change needs to be. Here, there is a challenge; whilst the 'ecological footprint' of the economy is already larger than the planet can provide for (Rees W. E., 1995, p. 343) there are still pressures to develop. There is also a chasm between theoretical notions of what a 'sustainable socio-technical system' might look like, and how the present 'socio-technical system' actually is configured.

Sibbet (2003, p. 8) advances the view that "*System creativity comes from resolving the structural tensions between visions and current reality.*" Here, the thesis perhaps talks of system innovation on two different levels; firms innovating the systems that they use to create value and deliver novel products (niche actors in transition) i.e. the business model 'system', and the actions of these 'systems' at the micro level contributing to an overall system change in a higher level system, that of the 'automobility' system. Here, there is a challenge at multiple levels. If business models are systems used to create value, that are in turn is subsystems of a wider automobility system (which is in turn is a subsystem of our global eco-social-economic system), how is sustainability of the whole considered? Voinov & Farley (2007, p. 104) assert "*...by sustaining certain systems beyond their renewal cycle, we decrease the sustainability of larger, higher-level systems.*" There is consensus that global sustainability is being compromised by the present global system of automobility from the evidence presented in this chapter but is the sustainability of the automobility system itself being undermined by the unsustainability of lower-level subsystems? Or by the business models of auto manufacturers? This is a question examined later in Chapter 3 [p.124] but should also be borne in mind when considering the next section.

This thesis will now move into a discussion on Sustainable Consumption & Production. There is a need for explicit recognition that consumers and producers can be considered as part of a consumption and production 'system'. Rittel & Webber (1973, pp. 156-157) writing about wicked problems note a RAND report by Hitch (1960, p. 19) which is crucial in the understanding of systems' objectives. They note a move to define systems '*in the syntax of verbs rather than nouns*' saying we should ask '*What do systems do?*' rather than '*What are they made of?*', and the most important question being '*What should systems do?*'. Such an approach can help in focusing on needs and reducing consumption.

### **1.1.2 Sustainable Consumption & Production**

Within the literature, Murphy & Cohen (2001), chart the rise in ‘consumption’ as an area of interest to those formulating sustainable development policy since the 1992 Rio Earth Summit. They identify that a whole chapter of the conference’s report was dedicated to examining how a ‘*seemingly endless stream of consumer desires*’ are largely responsible for causing global environmental degradation. They identify this conference report as a major catalyst for interest in and the development of the field of ‘Sustainable Consumption and Production’ [SCP]. The World Summit on Sustainable Development (2002) produced as a key outcome a commitment to promote more sustainable consumption and production patterns; central to this is a need to decouple economic growth from environmental degradation and resource use.

Murphy and Cohen (2001) identify that consumption is a problematic discourse, characterising it as having “*poor boundaries*” and “*ambiguous [...] core concepts*”, which leads to challenges in implementation. They note that policy dialogue has been “*muddled*” and “*poorly focused*”. - De ja vu? (See p. 2-5); indeed, these are common themes that crop up across the sustainability literature. Murphy & Cohen (2001) tackle “consumption” from a variety of disciplinary stand-points (Murphy & Cohen, 2001, pp. 5-8), but note that it is challenging to find working definitions of consumption that do not suffer from being either so broad that they do not offer prescriptive wisdom or too narrow that they provide no general applicability.

#### **1.1.2.1 Mobility: A Priority SCP Sector**

Tukker, Eder & Suh (2006, p. 184) conclude that ‘*focusing on the products with the greatest environmental impacts is viable and manageable*’. One of the products with the greatest attributable life-cycle environmental impacts is mobility. This is borne out by Tukker & Jansen (2006) and their review of the Comprehensive Environmental Data Archive (CEDA) of the EU25, which shows that 80% of the environmental impact of 280 various product groupings can be attributed to only 20% of the products. This leads Tukker, Eder & Suh (2006, p. 184) to the conclusion that, despite the vast number of products on the market, environmental product policy can make a radical difference by targeting ‘*a few*

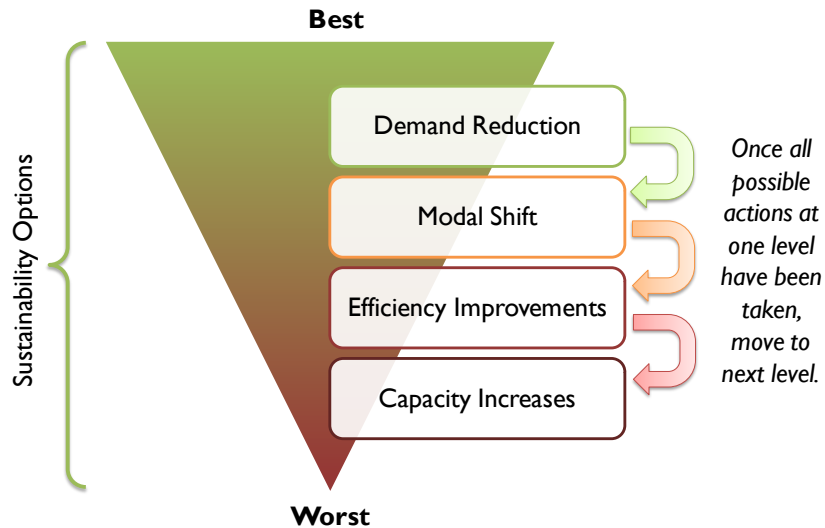
dozen *product groupings*' amongst which mobility would rank highly. As Tukker, Eder & Suh (2006) highlight, mobility (along with food and residential energy use) is one of the '*same limited number of consumption categories [that] are consistently revealed to be responsible for the largest share of impact*'. Tukker & Jansen (2006, p. 174) assert that in the EU25, transport contributes to between 20-30% of environmental impacts. Fuchs & Lorek (2002, p. 21) note that mobility is also one of the fastest growing consumption sectors globally.

Mobility encompasses a much greater range of socio-technical systems than just road transport; however, by share, the greatest proportion of energy and carbon dioxide impacts arising from mobility are the consequence of car usage (Newman, 2013, p. 458). Applying Tukker, Eder & Suh's (2006, p. 184) approach of focusing on the products with the greatest share of impact, the car is a logical place to start as looking across a range of studies. Tukker & Jansen (2006) find the common theme that fuelling and operating passenger cars accounts for the greatest contribution to the environmental impact of transport activities.

Cohen (2006, p. 23) notes how over the period of several decades critical assessment of the impacts of motor vehicles has evolved. Early criticism focused on the shortcomings of the internal combustion engine and its environmental impact; however, over time the debate has grown to encompass '*a more comprehensive appraisal of the sociotechnical system for providing mobility..*'

### ***1.1.2.2 Situating the Car In A Sustainable Transport Hierarchy***

There is a large and growing body of literature, which suggests that the current way that automobility and transportation is viewed will be forced to change. This is reviewed by Banister (2008, p. 75) who sets out an approach to best-practice sustainable mobility that focuses on reducing the need to travel; then, where there is a need to travel, shifting to the most efficient mode of transport combined with land-use policy aims to reduce demand before applying technology fixes. Banister's (2008) sustainable transport hierarchy is viewed overleaf in Figure 7.



**Figure 7 - Representation of a Sustainable Transport Hierarchy as articulated by (Sustainable Development Commission, 2011, p. 41)**

If the environmental arguments put forward in the introduction are accepted, it is only possible to conclude there is a radical need for a reduction in personal mobility, yet this is hard to reconcile this with ever burgeoning demand. Here, the debate turns from what social changes the science says is needed to make to lifestyles and what technology can deliver to what is politically feasible.

Strategies for demand reduction and modal shift are beyond the scope of this thesis. As was asserted in the introduction, this thesis appraises ULEVs as a ‘soft sustainability’ option (p.4); one that is imperfect by some metrics (and towards the bottom of Banister’s (2008) sustainable transport hierarchy) but perhaps considered more politically feasible; an improved position compared to the status quo. This change is driven neither by consumer demand, nor, as Newman (2013, p.459) notes does *“impetus for this trend [...] come from the automobile industry itself, but is, rather, a reaction to the influence of governmental regulations”*. Regulation as a driver for eco-innovation is explored on page 77.

Perhaps herein lies the rub, ULEVs could be seen as vehicles that neither the dominant regime wants to produce, nor do consumers currently want to consume (Newman, 2013, p. 460), and this is the challenge. Clearly if durable and sustainable solutions are to be found, public conception of mobility may need to change. This is a two sided bargain between producers and consumers, whose relationship with the car this thesis now considers, but this bargain is being brokered by outside regulatory forces.



### **1.1.2.3 The Role of Vehicle Consumers**

The advantages that cars offer as a personal mobility solution are compelling and powerful (Vergragt & Brown, 2007) and go some way to explaining the car's persistence. Moore, Staley and Poole (2010, pp. 561-567) assert "The automobile, as a mode of travel is unrivalled in its ability to allow individuals to optimise their travel choices". The flexibility of the vehicle and its statement of individual choice ties into deep social and cultural issues, [which form 'the landscape' in transitions (p. 54)]. Whilst unsustainable, these issues seem immutable and resistant to change. Newman (2013, p. 472) cites Rajan (1996, p. 6):

***Implicitly or otherwise, automobile use has typically belonged to the private domain of individual decision making, even though it is evident to all concerned that these personal decisions ... are themselves influenced by the collective outcome of countless individual and government decisions. Earnest civic debate on the social impact of automobiles is singularly uncommon.***

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Newman (2013, p. 457) provides a political account of the entrenched role of the vehicle in mobility discourse noting "...attempts to alleviate our present car trouble must locate the automobile within the pervading capitalistic ideology in order to gain a full appreciation of our current predicament." This thesis does not attempt to address these political challenges, accepting them as part of the landscape, but works within the framework of the existing prevailing political ideologies. In the parlance of transitions, changes at niche (p.59) and regime (p.56) levels will eventually affect the wider landscape (p.54). Central to the permanence of the capitalist neo-liberal settlement is the role of consumers (Comaroff & Comaroff, 2001, p. 2), who, whilst expressing concern about climate change, take few steps to modify their transport behaviour, lifestyles and purchasing choices. (Whitmarsh & Köhler, 2010, p. 428). How can this consumer behaviour be understood? Later in the thesis the role of different consumer segments in accepting new innovations to the marketplace is unpicked (p.78). The transitions framework also explores how consumers with specific and unusual needs can form early "niche" markets. These niches are expanded and built upon to eventually challenge regimes (p.77). However, whilst these help to understand 'early markets', widespread adoption requires consumption by the majority. The market still seems unready to consume ULEVs en-masse, so is the consumer to blame?

#### ***1.1.2.4 Are Consumers To Blame?***

Nieuwenhuis (2012, p. 35) asserts that, conventionally, the car industry has shifted blame for the products it makes onto the demands of consumers. Nieuwenhuis (2012, p. 35) goes on to contest that *'the customer is not a car designer or automotive engineer and can only choose from the products offered'*. Nieuwenhuis (2012, p. 35) goes on to cite the work of Hart (1997) as being an influential piece in challenging the mantra, stating that industry only responds to customer demand. Hart (1997, p. 76) pronounces that the *'responsibility for ensuring a sustainable world falls largely on the shoulders of the world's enterprises'*. He goes on to argue that corporations should drive change in consumer behaviour. It could be argued that the car industry has led customer demand, just not in the right direction from an SCP perspective. Perhaps this zeal for the automotive industry leading the consumer can be captured by the quote from Alec Issigonis, designer of the MINI *"The public don't know what they want – it is my job to tell them"*. Nieuwenhuis (2012, p. 35) reinforces this challenge by asserting that customers can only buy what is on the marketplace and supporting this with the historical evidence of a whole host of vehicles, which customers at one point in the past found met their needs. Of particular note is the reference to a range of micro cars (often termed "bubble cars") which was industry's' response to a time of perceived resource scarcity (with the Suez oil crisis); indeed, the Messerschmitt was unusual for a car of 1963 in being able to attain 80mpg (Motorcycle Mechanics, 1963). It would be easy to add to this list how smaller cars enjoyed a brief period of acceptance amongst North American consumers during the 1973 oil shocks, (Bresnahan & Ramey, 1993, p. 214). Here is a case in point of an industry poorly prepared to deliver consumer needs in the middle of landscape changes. Bresnahan and Ramey (1993, p. 215) in a detailed economic analysis of how the supply and demand of small vehicles was matched to the change in oil prices note how capacity in this period was mismatched with demand, and how the industry struggled to respond but could, and for a limited time, tried to. This begs the question, if the industry can produce greener cars, why doesn't it? Could it be that the very nature of the structure of automotive business models predisposes an industry to the relentless need to sell more, more, more?

### **1.1.2.5 The Car Industry: Engineering for Consumption?**

When examining why the present consumption of vehicles is unsustainable, it is important to understand that vehicles are consumed for more reasons than providing transportation. They are also a source of pleasure and signify social status (Nieuwenhuis P. , 2008; Vergragt & Brown, 2007, p. 1104). Nieuwenhuis (2008, p. 649) introduces the idea of “*technical vs. psychological durability*”. Indeed, a product that is less durable in its enduring appeal to consumers is no bad thing if your business model is focused around moving large volumes of product.

Indeed, almost from the very early days of the industry, there has been an unquestioned assumption that eventually everyone would own a vehicle; only more recently has this been challenged:

***No, sir, there is no such thing as a saturation point – not until every man, woman and eligible child in the country has an automobile.***

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**William C. Durant, 1910 quoted in (Koblenz, 2010)**

Consider how early developments in the marketing of vehicles have encouraged a culture of consumption. Nieuwenhuis (2008, p. 650) points to (Flink, 1988, p. 234) for an explanation of Sloan’s approach at General Motors, which since then has been adopted by much of the mainstream car industry. “*Consumer dissatisfaction with today’s car was engendered by the innovation of the annual model change, which called for major styling revisions every three years, functional or not, with minor annual face-liftings in between.*”. On page 129 on, issues such as the ‘*yearly model change*’ (Giucci, 2012, pp. 35,146) and its significance for the industry’s standard business model will be discussed, however, in a consumption context, consider how ‘*style obsolescence*’ (Whiteley, 1987, p. 3) has fed into a culture where consumers ‘*dispose of object and artefacts before one actually needs to.*’ Whiteley (1987, p. 3) cites an influential early work in this area, they cite as Arens & Sheldon (1932), written in the Great Depression. This is an upbeat exultation for manufacturers to encourage consumption through design. Whiteley (1987) cites them as saying: “*To understand that [obsolescence] has also a positive value; that it opens up as many fields as ever it closed; that for every superseded article there must be a new one which is eagerly accepted. [...] He turns in his motor car for a new one when there is no mechanical reason for so doing. He realizes that many things become decrepit in appearance before the works wear out.*” This has led

to what Nieuwenhuis (2008, p. 650) describes as the car “becom[ing] a fashion product, rather than a true durable.” Nieuwenhuis (2008) goes on to say “Cars are the most complex of consumer durables, yet they are not as durable as one may expect.” This lack of durability, inevitably results in waste, to the detriment of the environment. Whiteley (1987, p. 3) notes Arens & Sheldon (1932) euphemistically refer to the spoils as ‘progressive waste’ or ‘creative waste’. Now, it is no longer viewed as ‘progressive’!

Newman (2013, p. 457) notes that “The 20th century was the century of the car, in which its central position became locked in, enabling it to emerge as the de facto mobility leader for the 21st century.” However, Cohen (2006, p. 34) has speculated that “it is probably safe to aver that we are closer to the automobile’s obsolescence than we are from its initial mass commercialization.” Are ULEVs the industry’s answer?

#### **1.1.2.6 ULEVs: Consuming Less?**

In making an assessment of how ULEVs contribute to greater sustainability, this section has situated them within the wider consumption debate. ULEVs, in use, help to reduce the consumption of fossil fuels, a finite resource and mitigate against some effects of consumption of vehicles miles, namely GHG emissions. However, ULEVs are an artefact that is consumed; in sustainability terms, there are solutions that are superior to substituting ICE vehicles for ULEVs; demand reduction and modal shift.

Newman (2013, p. 464) questions as to whether making a socio-technical transition from conventional ICE vehicles to ULEVs is sustainable; is this not just substituting consumption of one item for another? However, ULEVs themselves have not yet proved popular with consumers. Newman (2013, p.460) notes that 2011 was supposed to be the ‘year of the electric car’ in Western Europe, yet accounted for only 0.09% of sales. Hydrogen vehicles are even further from the market. Why is this so?

Restating, this thesis’ approach of a ‘soft’ sustainability perspective: whilst a wider reconfiguration of the way mobility is delivered is desirable from a political perspective, how likely is the car’s demise given incumbent regimes? This thesis approaches ULEVs as symbolic of a changing regime, which in turn will influence broader landscape challenges. ULEVs are a component of sustainable mobility but not an end in themselves; with this firmly in view attention now turns to cleaner production.

### 1.1.3 Industrial Ecology

Industrial ecology can be seen as the practical field for the pursuit of more sustainable industrial systems. There are a number of literature reviews that cover the field of Industrial Ecology. O' Rourke, Kennedy & Koshland (1996) present a review of US literature on the subject. Den Hond (2000) also presents a more recent review, which informs much of this section. Later work by Agarwal & Strachan (2006) focuses on eco-industrial development initiatives globally, and evaluation of their performance, validating the approach through practical examples of its application. Den Hond (2000, p. 60) defines 'industrial ecology' as "*both a vision, a research field and a source of inspiration for practical work.*".

Den Hond (2000, p. 61) notes that there is not a clear '*demarcation*' of the field of Industrial Ecology. By way of evidence, den Hond (2000, p. 61) lists a range of authors whose interpretation of IE spans a range of disciplinary fields from the natural sciences, through a number of disciplines of business administration through to those studying themes such as 'consumption' within the realm of 'sustainability science'. In echoes of earlier discussion about the tensions implicit in the discourse of the field of sustainability (see page 2), industrial ecology is seen to embrace a diverse array of actors and a wide range of strategies from the incremental to the radically disruptive (O'Rourke, Connelly, & Koshland, 1996, p. 89). As noted previously, there are many advantages to a systemic approach to problems [p.22]. What distinguishes Industrial Ecology from other approaches to sustainable technology development is its holistic focus on "industrial systems" (den Hond, 2000, p. 60), with other approaches taking a more narrow focus on either products or processes. However, these other approaches, for example 'material flow analysis' (MFA), 'life-cycle assessment' (LCA) [already seen on p.10] and design for environment (DFE) can inform or be subsumed into industrial ecology studies when situated as part of a wider evaluation of the industrial system.

What unites scholars in a multifarious range of disciplines in gazing through the lens of industrial ecology is their shared interest in the flow of materials and energy through industrial systems. To find some commonality in the range of approaches to the subject, den Hon (2000 p.61) advances Garner & Keoleian's (1995) attributes of Industrial Ecology as being an uncontroversial view of the field.

Garner & Keoleian's (1995) define Industrial Ecology as:

1. *A systems view of the interactions between industrial and ecological systems.*
2. *The study of material and energy flows and their transformations into product, by products and waste materials through industrial and natural systems (industrial metabolism).*
3. *A multi-disciplinary approach.*
4. *An orientation toward the future.*
5. *A change from open, linear processes to closed, cyclical processes so that the waste from one sector is used as an input for another.*
6. *An effort to reduce the environmental impact of industrial systems on ecological systems.*
7. *An emphasis on the harmonious integration of industrial activity into ecological systems.*
8. *The idea of making industrial systems emulate the more efficient and sustainable natural systems.*
9. *The identification and comparison of industrial and natural systems hierarchies, which indicate areas of potential study and action.*

Graedel & Allenby's (1997) book of the same name examines 'Industrial Ecology and the Automobile'.

In some ways, there are parallels to how the discourse around the environmental impact of the automobile and the wider industrial ecology have developed. By way of evidence, the discussions around the environmental impact of the car initially focused on the internal combustion engine and reducing its impact (Cohen, 2006, p. 26). In time, this has grown to encompass a much wider debate about production, consumption and the proper role of the vehicle in future mobility systems. Analogously, industrial ecology, has grown out of the roots of looking at "*end of pipe' pollution control methods towards holistic strategies for the prevention and planning of more environmentally sound industrial development*" (O'Rourke, Connelly, & Koshland, 1996, p. 89). From this, it is possible to aver more general characterisations about how discourses of sustainability have evolved,

Agarwal & Strachan (2006, p. 19) have discussed the challenges of evaluating the success of industrial ecology initiatives. They note that, whilst the field of literature is currently developing apace, there are significant challenges in developing a generic methodology that can be applied across cases. This thesis does not set out to be a comparative study of 'Industrial Ecolog[ies]' but it does touch on many overlapping themes which are relevant to this study. Particularly, one of the strengths of the business model is that it considers linkages both within the firms' functions but also situates the firm as part of a wider industrial ecosystem, encompassing both consumers and suppliers, on the micro level.

What is clear is that radically different technologies will require different industrial ecology[ies] to support them, impacting the business model of firms. The issue of new IEs is explored overleaf.

### 1.1.3.1 The Industrial Ecology of Alternative Vehicles

Chertow (2001, p. 15) professes “the notion that technological choice is crucial for environmental improvement lies at the core of industrial ecology”. Yet, in the case of automobility, the same limited choices seem common place. Nieuwenhuis & Wells (2007) discuss the dominance of the all-steel bodywork as the cornerstone of the modern car industry (discussed later on p.131), with another dominant technological feature is the internal combustion engine. There are a range of alternatives, or hybrid options, however, some will require radically different industrial ecologies (see Table 3).

Technology	Incremental Innovation	Radical Innovation
LPG	◆	
CNG	◆	
Biodiesel	◆	
Bioethanol	◆	
Hydrogen IC	◆	
IC-electric hybrid	◆	
Battery-electric		◆
Fuel Cell		◆

Table 3 - Alternative fuels vs powertrain: incremental vs radical innovation  
Original Source: (Zapata & Nieuwenhuis, 2010, p. 16)

Zapata & Nieuwenhuis (2010, p. 15) posit that what differentiates incremental innovation from radical innovation in the automotive industry is the need for widespread capital investment in supporting infrastructure. The challenge has often been characterised as a ‘chicken and egg’ situation (Romm, 2006; Melaina, 2003; Ogden, 1999). Melaina (2003) outlines the three main dimensions of this problem; customers will not purchase [alternative fuel vehicles] unless adequate fuelling is available, manufacturers will not produce vehicles that people will not buy (see consumption discourse p.29) and fuel providers will not install [alternative fuel] stations for vehicles that do not exist.

The companies which presently provide motor vehicle fuel have large sunk investments in the infrastructure and distribution network required to deliver services for the present automotive paradigm. It is therefore not unsurprising that they are reluctant to invest in developing a whole new infrastructure for a range of technologies that have not been brought to market. Meanwhile, the main vehicle manufacturers have been understandably reticent about developing product lines for which there exists at present no refuelling infrastructure.

#### **I.1.4 Sustainability: The Corporate Perspective**

The goal of the typical publicly listed company is to create value for their customers, resulting in profits for their shareholders. Accordingly, many discourses [see examples below], translate the need for sustainable development into business goals. Furthermore, the 'firm' is an important unit of enquiry, as businesses are the vector for the introduction of new products and innovations. Gladwin Kennelly & Krause (1995) identify the transformation of management theory and practice to positively contribute to sustainable development as "*the greatest challenge facing the Academy of Management.*" Since their landmark article, there have been numerous examinations of the corporate sustainability perspective; how businesses can contribute to sustainable development and benefit from it.

The world of commerce has been quick to realise that there is profit that can be realised from the new all-pervasive market in green goods and services (Weybrecht, 2010, pp. 21-29) and the market for green technology has exhibited consistent growth. Whilst many have articulated criteria for corporate sustainability, Dyllick & Hockerts (2002, p. 135) argue that, too often, the focus has been on how to make the 'business case' for sustainability, that is to say, improving economic sustainability through '*attention to social and environmental issues*'. They argue that there is undue focus on 'eco- and socio-efficiency', which makes the business case for sustainability, but insufficient attention is paid to other measures which make the Natural and Societal cases for sustainability. Young & Tilley (2006, p. 402) outline six dimensions to sustainable business that they have identified through the literature that a sustainable enterprise needs to fulfil: "*eco-efficiency, socio-efficiency, eco-effectiveness, socio-effectiveness, sufficiency and ecological equity*"

The business case for corporate sustainability has been reviewed by Salzmann, Ionescu-somers & Steger, (2005). Here they suggest a particular problem in that it is not conclusive, nor straightforward, that environmental and social goals translate into financial performance. There are competing frameworks (Salzmann, Ionescu-somers, & Steger, 2005, p. 29); some suggesting positive relationships, others neutral and some negative correlation between pursuits of these two goals. This results in a diversity of commercial responses to the challenges posed by sustainability.



#### ***1.1.4.1 Sustainability: Diverse Business Responses***

Whilst many VM's acknowledge the need to move towards more sustainable practices, there is a spectrum of beliefs about what degree of change is required and what responses are appropriate. To generalise, larger manufacturers err towards thinner versions of sustainability, whilst some smaller manufacturers' businesses' are motivated by the desire to address some of the 'thicker' sustainability challenges with a more radical product offering. This diversity is problematic from a methodological standpoint; how can 'apples and oranges' be compared when looking at individual firms? This is dealt with in more detail on pp.182,185 & 187, however, through using a systemic framework, the Business Model Ontology (Osterwalder & Pigneur, 2002), common factors in all firms are considered through a common lens. This diversity of understandings of sustainability can perhaps account for the variety of vehicle manufacturers responses to the challenge of sustainability made tangible through their product offerings. Given this diversity of views, in seeking to understand how to improve the 'sustainability' of automobility, there perhaps has to be an acceptance that these many different standpoints will result in a diversity of solutions. This may be no bad thing from the perspective of sustainability. Wells (2010b, p. 305) argues that the industry may be emerging from a period of 'technological monoculture' and that diversity could provide resilience in the search for sustainable alternatives. Diversity in relation to automobility is a theme. Wells (2010b, pp. 39-98) discusses this at great length. Diversity is commonly observed in nature as a way of providing resilience. Maffi (2007, pp. 267-277) proposes that, in the social sciences, the field of 'biocultural diversity' proposes an 'inextricable link' between ecological diversity and social and cultural diversity, with processes of diversity leading to more sustainable outcomes through evolutionary mechanisms. However, Rhys (1977, p. 256) noted that diversity "is achieved at the expense of fragmented, high cost production"; modern flexible manufacturing methods may go some way to overcoming this. That said, 'the cost of diversity' is still a relevant theme. Harper & Wells (2012) question whether diversity results in a 'template for the future', or in 'squandered resources'? Diversity can be viewed as the result of developing solutions to meet a broad range of objectives. Some radically different vehicle technologies will require new 'Industrial Ecologies', whilst some less radical solutions can work with existing infrastructure.

## **I.2 Defining the Ultra Low Emission Vehicle (ULEV)**

There is a variety of terminology and acronyms that are used to refer to vehicles with emissions that improve upon present vehicle average emissions, some of this terminology will be explored on the following page in section 1.2.1. In this thesis, the term 'Ultra Low Emission Vehicle' has been applied to the product innovation that this thesis concerns itself with.

The definition used in the UK by the Office for Low Emission Vehicles is as follows:

***“An ULEV emits extremely low levels of carbon dioxide (CO<sub>2</sub>) compared to conventional vehicles fuelled by petrol/diesel. They typically also have much lower or virtually nil emissions of air pollutants and lower noise levels. Since 2009, the Office for Low Emission Vehicles has considered ULEVs as new cars or vans that emit less than 75 grams of CO<sub>2</sub> from the tailpipe per kilometre driven, based on the current European type approval test. Other definitions exist that suggest 50g CO<sub>2</sub>/km is a more appropriate threshold.”***

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**OLEV (2013, 16)**

This term chosen by the UK Government 'Office for Low Emission Vehicles', is emissions based and 'technology agnostic'. It specifies the standards to be reached in 'output rather than technology terms' (OLEV, 2013, 11). This thesis takes the same position of considering a broad range of technologies.

***“It is not Government’s role to identify and support specific technologies at this early stage. Ultimately, the mass market transition to ULEVs will happen through industry developing and bringing products to market and consumers deciding which products they wish to buy. The emerging consensus in the automotive industry is that a portfolio of solutions will be required to decarbonise road transport.”***

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**OLEV (2013, 7)**

Whilst the term 'ULEV' is used throughout this thesis, there is also discussion of a range of vehicles and mobility concepts that perhaps would not strictly fall under the definition of ULEV. By way of example, some large, heavy, hybrid luxury cars might not achieve the strict definition of 75kg/CO<sub>2</sub>/km.

Whilst some of the vehicles included in this thesis do not meet this 'absolute' definition, they still represent a 'relative' improvement compared to the average emissions of those marques, for that reason, ULEV has been interpreted more loosely than the strict interpretations of OLEV's definition.

## 1.2.1 ULEV Terminology

There are a number of different terms that are used to refer to vehicles with lower emissions than conventional vehicles. As one of the early markets where development of clean vehicles has been driven by legislation, California has been a leader in emissions standards, and has evolved its own lexicon of clean vehicle terminology. In particular, in the US, there are a number of designations referring to different vehicle emissions standards. As these terms are used widely in the literature the following Table 4 presents some of the terminology that is commonly used in the US.

Acronym	Definition	Locale	Definition	Reference
<b>TLEV</b>	Transitional Low Emissions Vehicle	California	Standard phased out in 2004. Replaced by LEV.	CARB (2014)
<b>LEV</b>	Low Emissions Vehicle	California	Minimum standard for all vehicles sold in Californian market from 2004 on.	CARB (2014)
<b>SULEV</b>	Super Low Emissions Vehicle	California	90% Cleaner than average new model year vehicle	CARB (2014)
<b>PZEV</b>	Partial Zero Emissions Vehicle	California	Meets SULEV standards, but also has evaporative emissions control.	CARB (2014)
<b>AT - PZEV</b>	Advanced Technology – Partial Zero Emissions Vehicle	California	Meets PZEV requirements by also fulfils some of the ZEV criteria. E.g. CNG vehicles & some hybrids.	CARB (2014)
<b>ZEV</b>	Zero Emissions Vehicle	California	98% Cleaner than average new model year. No tailpipe emissions.	CARB (2014)

Table 4 - Some acronyms used to refer to low emissions vehicles.

The following terms in Table 5 are also used to refer to specific technologies.

Acronym	Definition	Locale	Definition	Reference
<b>BEV</b>	Battery Electric Vehicles	California	An electric vehicle using batteries for energy storage.	CARB (2014)
<b>EV</b>	Electric Vehicle		See BEV.	
<b>H<sub>2</sub>FCV</b>	Hydrogen Fuel Cell Vehicle	California	A vehicle which runs on hydrogen fuel, using a fuel cell to generate electricity for an electric drivetrain.	CARB (2014)
<b>H<sub>2</sub>ICE</b>	Hydrogen Internal Combustion Engine Vehicle	California	A vehicle with an internal combustion engine which is designed to run on hydrogen fuel.	CARB (2014)
<b>HEV</b>	Hybrid Electric Vehicle	California	Combines an internal combustion engine with an electric drivetrain.	CARB (2014)
<b>PEV</b>	Plug-in Electric Vehicle	California	Vehicles that can be plugged in to charge; includes Battery Electric Vehicles & Plug in Hybrids	CARB (2014)

Table 5 – Some acronyms used to refer to low emissions vehicles technologies

### **I.3 Research Questions**

The central question this research hopes to address is:

#### **What Is The role of Business Model Innovation in Ultra Low Emissions Vehicles transitioning To Market?**

Within this overarching question, which is deliberately framed to be ‘exploratory’, there are sub-themes that this thesis seeks to explore in more detail. The research is deliberately framed in a way that is ‘discovery driven’, as opposed to ‘confirmatory’ (Zikmund, Babin, Carr, & Griffin, 2012, p. 51). Furthermore, the research aims to explore what appears to be a research ‘opportunity’ discovered by the researcher, rather than targeting a specific ‘problem’. These are issues that will be explained in greater detail in Chapter 4: Research Methodology p.174. Surrounding each theme is a “constellation” of questions, again this approach reflects the fact that this early-stage research sets to explore territory and a research agenda that is not already clearly defined or explored.

Some of these questions follow as a result of analysis of the sustainability context, which has been set out in this introduction. In the next chapter, the existing literature covering theoretical approaches that the researcher has identified as relevant to the understanding of the research question is discussed. Some of the questions that comprise the sub-themes are formulated with relation to gaps in the literature, which are addressed in the next chapter: the Literature Review. Some questions have been shaped by understanding of the existing Industry – discussed in Chapter 3 p.124, and also by Methodology – discussed in Chapter 4 p.174.

- 1.** What is the significance of the ‘Business Model’ and ‘Business Model Innovation’ in the transition process? How can the concept of business models be positioned in respect of the transitions framework and what links can be drawn between these two theoretical models?
- 2.** What ‘types’ of business model can be identified in the UK marketplace? It is pre-supposed that scale in terms of production volume will be one of the major factors differentiating the business models that firms deploy; however, what other factors can be used to differentiate

and understand business models. What evidence is there for innovative business model configurations and components being deployed in the UK car industry?

3. Are there components of business models which can be analysed in a “standalone” manner; elements of business models which can be examined in isolation from the gestalt. If so, what innovative business model features can be identified.
4. What pathways for transition can be identified, and how do these relate to the existing literature? Can any new mechanisms of transition be defined, or is it possible to contribute to the understanding of existing transition pathways.
5. What is the nature of the relationship between ‘Incumbent’ and ‘Insurgent’ firms? If the Insurgent firm’s business models are more radical and different than the traditional industry, how do these ideas transition to the marketplace?
6. If ‘Business Models’, ‘Vehicles (as innovative niche products)’ and ‘Vehicle Processes’ are all consciously designed, in what order are these processes undertaken? How can this inform our understanding of the process of innovation? What can this tell us about niche actor behaviour?

### **1.3.1 Focus of this Thesis**

There are manifold, mundane and practical reasons for the UK focus of this study. The researcher, being born a British citizen, is already familiar with the UK context. Given the resources available to the researcher, there is pragmatism to focusing on businesses that are accessible to the researcher. In order to inform a rich and detailed study, there are many methodological reasons why familiarity with the cultural, governmental and social context aids in formulating a detailed study. The methodologies selected, being qualitative in nature and focusing on interviews and textual data also require a competency and understanding with language. However, by rooting the study in the global context with this chapter and by examining the industry in an international context and considering wider developments within automotive business models, it is hoped that the study considers the broader automotive landscape and avoids the trap of being Anglo-centric and parochial. Being reflexive, there are also personal reasons for the UK context; the researcher's father and grandfather having both worked in the UK car industry give the researcher a strong interest in the industry. In speaking to the policy arena, there are many reasons why this question is relevant. In the period since the recent economic recession, there has been a number of intersecting dialogues in the political area; the need to rebalance the UK economy, the need to create jobs and the need to create economic growth. This study, to varying degree speaks to all of these themes.

### **1.3.2 Limitations & Boundaries of the Study**

Whilst the environmental impacts of motor vehicles are manifold in this study, the focus is on ultra-low [carbon] emissions vehicles. The broad term 'ultra-low emissions vehicle' (ULEV) is used throughout. 'Ultra' implies a step-change in emissions but the degree of change is not specified. In part, the justification for this is, as Nieuwenhuis (2012, p. 21) identifies, CO<sub>2</sub> "...can be regarded as proxy for the wider environmental impact of the car". Given the many views of sustainability, and that this is a study in business and management, not engineering and technology, the decision has been taken to be technology-agnostic, with respect to what vehicle technologies.

### **I.3.3 Contributions to Knowledge**

Marshall & Rossman (1989) assert that research must be useful in three distinct ways; it must contribute to knowledge, the research should be useful to practitioners and the research should speak to relevant policy arenas. It is important to note that the degree to which research speaks to each of these audiences varies depending on the type of research being conducted. Whilst this thesis necessarily is written as a piece of academic research speaking to the business and management literature, it is clear that the contemporary nature of this research makes it very relevant to the automotive industry, as well as wider debates as to the structure of the UK economy. Indeed, the research methods applied have been consciously selected to produce a work that, whilst academic in nature, is wholly engaged in the examination of practical problems that industry and economy faces.

In interrogating business models within the automotive industry, this is as much a piece of “research for management” as much as it is “research into management”. This is consistent with the methodological approach adopted of ‘*engaged scholarship*’ (See page 192).

Whilst not written as a critique of current policy, it is clear that there are some conclusions of this work that should speak strongly to a policy audience and there are themes about the nature of business models and industrial organisation which are relevant to consideration of UK industrial policy. The transition and development of a UK ULEV industry are contemporaneous with wider discussion in UK society about the structure of the UK economy, a need for rebalancing away from finance and services to making “tangible products” again (Westlake, 2013). In addition with sectoral rebalancing, there are also spatial implications to rebalancing growth (Gardiner, Martin, Sunley, & Tyler, 2013). Growth around finance and services is concentrated around Greater London; however, the automotive industry has traditionally found its home in the Midlands and, more latterly, the North East. Growth in the automotive industry can contribute to spatial economic rebalancing.

It is self-evident the largest contribution of this research is in attempting to address the themes of the research questions but there are numerous smaller contributions to knowledge that address issues of methodological development, most notably the application of the novel citation network analysis.

## **I.4 A Guide To The Thesis**

The preceding sections comprise a brief journey through the foundations that underlie the rationale of this thesis. Thus far, in setting the scene for the topic under examination, the thesis has largely focused on ‘the bigger picture’. In the parlance of transitions theory, up until now, this thesis has looked at the “landscape” (p.54), developments that create a pressure for “regime change” (p.56) in the vehicle industry. The preceding sections also touch upon some of the theory that will be introduced to understand and interpret the findings of the empirical case studies.

A deeper understanding of how some of these theoretical elements nest together is impossible without a more in depth explanation of the literature examined, which will come in Chapter 2 (p.47 onwards). However, at this juncture, it is important for the reader to have an understanding of the direction of the rest of the text, and to see the way ahead with how the different theoretical underpinnings integrate to form a coherent whole. Three fields of literature, which are crucial to the theoretical understanding of the problem are explored. The first is the ‘technology transitions’ literature, the second is a brief look at the ‘innovation’ and ‘technology management’ literature, whilst the final is a look at the ‘business models’ literature, with a focus on Osterwalder’s ‘Business Model Ontology’.

A useful tool that draws the theory base of the study together is the visual map to the thesis, which is presented at the end of the literature review in Figure 36 on p. 119. It is an attempt to represent graphically the interrelated theoretical approaches taken to examining the research area. Graphical tools are encouraged in systems approaches to problem solving, in order to visualise the interconnectedness of concepts ideas and things, so this can be considered as a “Rich Picture” of the thesis.

Chapter 3 p.124 onwards is practice-orientated and examines in more depth the evolution of the automotive industry’s business model and some of the challenges the automotive industry faces to its present business model. Having examined these endogenous factors through the tripartite lens of sustainability, namely looking at Economic, Environmental and Social factors that are both affecting the



industry and also shaping its products and potentially its business models, these factors are used to construct a rationale for the need to transition.

In Chapter 4 the methodology used to conduct the research is examined. The empirical research consists of a number of embedded cases, which are in turn divided into two main case studies. These cases are differentiated by the scale of the firms, yet both cases are embedded in a common context. The qualitative methods used to construct the cases are also set out.

Context is important to the interpretation of case studies. It also forms the 'landscape' (p.54) against which transitions are set. In Chapter 5 the common milieu in which both of the cases are constructed is examined. The UK national context provides the backdrop for firms trying to bring ULEVs to market. The analysis of this setting is done through the lens of a 'STEP' analysis.

Chapter 6, the first case study, focuses on vehicle manufacturers that are considered to be traditional automotive industry giants. The label these have given seems to best fit the scale of these enterprises and is Trans / Multi National Corporation Vehicle Manufactures. Or TNC/MNC VMs.

Chapter 7, the second case study, by contrast focuses on the array of 'small to medium sized enterprise' (SME) vehicle manufacturers operating in the UK. They are radically different in scale and are all indigenous 'home grown' enterprises. This group is particularly interesting as a fertile hotbed of "niche innovation" and different approaches, some of which may eventually be part of a transformation of the UK vehicle manufacturing regime.

In Chapter 8 is the chapter in which analysis is made and conclusions are drawn, that includes what can be learnt from practical, academic and policy perspectives on the research question.

In Chapter 9 further research avenues that have been prompted by themes explored are discussed.

The appendices contain the works references in this thesis in Appendix 1, an explanation of the Citation Network Analysis Methodology in Appendix 2, a list of the source data in Appendix 3, the Interview Question Pool in Appendix 4 and documents relating to the research ethics in Appendix 5.

## **I.5 Chapter Summary**

Chapter One, provided the 'frame' through which the rest of the thesis can be viewed. By exploring approaches within the literature to sustainability, a solid case was built that our present approach to automobility is unsustainable.

Section 1.1 started by considering the discourse of 'sustainability' as one that is broad, problematic and rife with imprecision. It considers multiple interpretations of sustainability but concluded that whilst there are varying interpretations of what 'sustainability' means, there is consensus that working towards 'sustainability' is a process which policymakers and academics agree with as necessary to tackle a range of environmental problems. Anthropogenic climate change and fossil fuel scarcity were identified as particular issues facing the automotive industry.

The identification of key consumption and production sectors was seen as being key to focusing on the areas of activity with the most environmental impact, and in this respect transport figured highly. Personal mobility was identified as problematic – in that it is an enduring part of our transport mix but a less favoured option environmentally. ULEVs were explored as one way of trying to improve the sustainability of personal automobility. This established the rationale for Ultra Low Emissions Vehicles, which section 1.2 set out to define.

Section 1.3 defined the work of this thesis through the research questions that are to be explored more fully in the empirical work relating to the two case studies (Chapters 6 & 7) which are framed by the UK context, which will be explored in Chapter 5. Section 1.3 also set out the research questions which will be used as the basis for the Analysis in Chapter 8, and Conclusions in Chapter 9.

Section 1.4 provided a guide to the structure of the thesis, and how the components of the thesis will relate to each other.

The next Chapter explores the theoretical basis for the research, looking at business and management theory that is relevant to the problem being explored. The subsequent Chapter 3, takes this theory and relates it more specifically to the automotive industry.

## **Chapter 2: Theory Base for the Research Innovation & Transitions: Technical & Business Model Perspectives**

### **2.1 Introduction to the Literature Review**

The previous chapter introduced the research question; this in turn leads to the six sub-themes that have been identified for further exploration. These themes have been constructed in part with reference to the theory base for the research, which are explored in this chapter, and partly with reference to the practical base for the research, which are explored in the next.

This chapter sets out the theoretical basis for the research. It starts with an exploration of the literature surrounding socio-technical transitions. This literature is used to interpret the macro-level changes that occur in industries and sectors undergoing radical change. Also explored are those factors which retard or stand in the way of transition. This provides a frame through which to view the cases. The innovation process provides a micro-level lens with which to view the processes taking place within the firm, situating innovation as, not just the introduction of new products, services and processes, but also of new business models. Finally an attempt is made at drawing the different theoretical traditions explored together into a coherent view of how they explain different aspects of the cases.

The companion of this 'theoretical' chapter, Chapter 3, provides practical context to the theory. Here, the literature which is evaluated in this chapter is used to interpret and understand the evolution of what is considered to be the dominant character of the present automotive industry business model, the basis of the business model used globally by volume vehicle manufacturers. By way of counterpoint, the business models of smaller firms, and emergent new business models which may provide insight into alternatives for the evolution of the industry are also examined.

In exploring the literature, reference is also made to Chapter 4, which deals with the Research Methodology. Here, a tool 'Citation Network Analysis' is examined, with which the researcher experimented at an early stage of the research to explore the business models literature. This is explored on p.185.

## 2.2 The Nature of Technological Change & Continuity

Windrum (2003, p. 291) contrasts the view of early economist Alfred Marshall that '*nature does not leap*' with Schumpeter's view that '*evolution is lop-sided, discontinuous, disharmonious by nature...studded with violent outbursts and catastrophes...more like a series of explosions than a gentle... though incessant transformation*' (Schumpeter, 1939, p. 102 in Windrum 2003, p.291). As will be seen later in section 2.4.6 Continuous vs. Discontinuous Change (page 84), innovation is not a constant. It can happen incrementally (as in the incremental improvement of the emissions from internal combustion engines) or it can be sudden and disruptive, when new technologies quickly surpass old. Schumpeter coined the concept of "*creative destruction*" where old regimes are swept aside to make way for the new. Understanding the nature of progress and innovation is fundamental to the appreciation of socio-technological change, which is the lens this literature supplies has applied to the motor vehicle industry.

This view starts from the position that the internal combustion engine, the design of vehicles in the mainstream car industry, the business models that the industry employs and the arrangement of social and civic institutions that support the vehicle as presently conceived are suffering from technological "lock in" (p.49). Given the range of factors that have been explored in the introduction, there are compelling drivers for change; however, the technology solutions used to deliver mobility have remained stable throughout the latter half of the twentieth century. How will this paradigm change?

The term 'ULEV' captures a range of technologies that could potentially radically disrupt the present 'locked in' technologies, but they have not yet won the hearts and minds of the mainstream. Schot & Geels (2008, p. 537) refer to work by Mokyr (1990) which considers new technologies to be "*hopeful monstrosities*", (also supporting this with Rosenberg's (1976, p. 195) observation, that at the point of invention, technologies are often very crude compared with the eventual product that reaches the mass market). Schot & Geels (2008, p.537) go on to say: "*They are 'hopeful', because product champions believe in a promising future, but 'monstrous' because they perform crudely*". The best state-of-the-art ULEVs are far from crude, and to understand why they are yet to reach mainstream consumers there is a need to unpick the nature of socio-technical change in order to "unlock" their potential.

### 2.2.1 Path Dependency

'Path dependence' shapes and constrains viable options based on history: "*Prior choices can place limits on what can be done today*" (Lovio, Mickwitz, & Heiskanen, 2011). Path dependence creates continuity in systems that support the status quo. Geels (2004, p.912) notes the stability and path dependency of socio-technical systems makes it challenging for radical innovations to emerge.

There is risk in trying to "pick winners". The last section considered that ULEVs are not a case of one technology competing against conventional ICE vehicles but a range of different technologies. In understanding the transition, there is a need to be mindful that today's decisions shape future options. This is not the first time that a range of technologies have competed for dominance. Kirsch's (1996) thesis is that, before the dominance of the internal combustion engine vehicle, there was a window of opportunity where one of a number of technologies could have risen to prominence. Kirsch believes that there was a window before 1902, when "*electric and, to a lesser extent, steam vehicles may have played an important enough role in the automotive system to have precluded the total dominance of the gasoline automobile*". Kirsch (1996, 346) identifies a number of factors and many of them relate to the business model of automobility (although not explicitly stated as such), not just the technology.

The industry is at a similar point today as different ULEVs jostle for technology leadership. It is interesting to consider the battle between various standards in other sectors. The battle between Betamax and VHS, and the continuing domination of the QWERTY keyboard (Dixon, 2008) provide a case in point, that the technically superior standard is not always the one that comes to dominate. Dolfsma & Leydesdorff (2009) suggest, through an analysis of break-outs from technological lock-in, that often a 'third' selective force outside of the market or technology is required to break the stranglehold a dominant regime creates (Regulation as a third force is reconsidered on p.77).

Genus & Coles (2008, p. 1448) caution that "linear" views, such as path dependency, do not give sufficient weight to factors such as agency and politics. However, the technology transitions literature does give insight as to how disruptive innovations can break through destabilising regimes and shape landscapes in a way that considers a range of social actors and socio-technical regimes.

### 2.2.2 Technological Lock-In

Cowan & Hultén (1996, p. 63) assert that ‘technology lock-in’ is seldom consciously instigated, often arising as the result of “...an accident, a haphazard marketing gadget, or a political problem demanding immediate action.” However, trigger events are only the catalyst for a process that builds over a greater period of time, creating stability for a given technology. Verbong & Geels (2007, p. 1215) cite that some of the causes of lock-in as “vested interests, ‘organizational capital’, sunk investments, stable beliefs”; Organisations build capabilities around technologies and invest time and human resource into them.

Unruh (2000) terms the specific factors that lock-in fossil fuel technologies as ‘carbon lock-in’. Unruh (2000) identifies ‘barriers to diffusion,’ resulting in socio-technical stalemate with respect to low carbon technologies. He describes the current carbon based regime as “possibly the largest techno-institutional systems in history” noting that it is without precedent.

Cowan & Hultén (1996, p. 63) note how it is *knowledge of technologies* that results in the lock in, as learning by ‘doing’, ‘using’ and knowing ‘about pay-offs’ results in a snowball effect where one technology gains advantage over others. This is a point also developed by Geels (2004, p. 910) who explains how knowledge is “cognitive capital” and a store of knowledge built up about one technology will encourage a reluctance to look at others if this means that hard won knowledge capital is lost. It is important to note that this knowledge is accrued by both *users* and *producers* of a new technology.

One pertinent question is how much improvement does the new technology need to offer over the old to escape lock in? This is an issue that Gourville (2006) has explored and is revisited on page 80. Cowan & Hultén (1996, p. 65) relate the example that the 20-30% improvements of the DVORAK keyboard over QWERTY are insufficient to encourage users to switch. Writing before the transitions literature had risen to prominence, they suggested six things that could prompt radical change:

1. A ‘crisis’ in the existing technology. (Such as occurred with pesticides, DDT e.t.c.)
2. Regulation (Such as occurred with CFCs, refrigerants and the ozone layer).
3. A technological breakthrough that radically lowers prices of ULEVs.
4. Changes in taste. (i.e. if environmental awareness suddenly become the fashion).
5. Growth of niche markets (A theme that reappears in transitions [p.61])
6. Scientific breakthroughs (Putting pressure on old technology).

### 2.2.3 Transition Failure in the Automotive Industry

Wells & Nieuwenhuis (2012, p. 1681) observe “the [automotive] industry has shown resistance to change notwithstanding the apparent imperatives for radical action or the multitude of attempts via socio-technical experimentation to nurture strategic niches”. Whilst it is possible to look at more generalisable factors, such as path dependency and technology lock in, they provide an account that is specific to the sector.

Some of the dominant characteristics of the present automotive industry have already been explored through the work of Urry (2004) [see page 24]. Whilst this highlights the character of the industry’s domination, it does not completely capture why the industry fails to transition. Wells & Nieuwenhuis (2012, p. 1681) provide six reasons; four intrinsic to the industry and two that take into account broader reasons external to the industry. The points that have hitherto not been covered adequately will be expanded upon.

1. The “combination of product technology, process technology and product design organizational design to create a universally powerful business model” which “continues to act by providing significant barriers to entry”. The business model of the industry is explored in more detail in Chapter 3 (p.124).
2. The scope for refinement of the ‘product, process and design’, enabling continuous improvement (mitigating the need for radical change) as well as refinements within the industry through M&A, collaborations and organisational refinements such as platform sharing. Again, the evolution and refinements to the industry business model are covered in Chapter 3.
3. The “institutional isomorphism” of the automotive industry. This results in a resistance to adapt with conformity being preferred. Some of this is internal to the industry, but some is external as a result of the web of relations, partnerships and supply chains that comprise the present industry. (expanded upon below)
4. The industry has been able to “manage” its own change. This could be through acquisition of threats (which Wells & Nieuwenhuis (2012, p.1684) describe as “niche capture”), lobbying, influence over the regulatory sphere. Some of this control arises as a result of the fifth factor.
5. The enormity of the industry and the contribution to the economy that it makes has allowed it “to enjoy privileged status”. This has helped it in securing favourable legislation, and even financial support from government.
6. The cultural status of the car and its position in respect to consumers and society (which has already been well established and explored)

Institutional isomorphism is a term that has been advanced by DiMaggio & Powell (1983). They define isomorphism as "constraining process that forces one unit in a population to resemble other units that face the same set of environmental conditions". Institutions seeking legitimacy aim to emulate and fit with others acting in the same domain. This results in sectoral homogeneity. Firms are subject to normative pressures from others in their industry. DiMaggio & Powell (1983) outline a range of factors with lead the condition of sectoral institutional isomorphism.

Wells & Nieuwenhuis (2012, p.) assert that "history is replete with attempts to challenge the technological orthodoxy or business logic of the automotive industry". They outline a range of ventures that have sought to challenge the conventional industry's business model: [where these cases are covered in this thesis, page numbers are given]: *Think*, *Indego*, *Ridek* (p.163), *Local Motors* (p.158), *MDI Air Car* (p.164), *EcoMotors*, *ZENN*, *ZAP*, *Tesla* (p.158), *GEM*, *REVA*, *ElectricBlue*, *Riversimple* (p.349), *Bright Automotive*, *BYD*, *Better Place* (p.170),  *Loremo and Axon Automotive* (p.307). Arising from this, they ask two questions that closely mirror the research themes this thesis seeks to explore and the case study structure.

- In order for technological transformation to occur, is it necessary to restructure the automotive industry as a whole and the business models of its participants?
- Alternatively, can the industry bring about a technological transformation without the need to make fundamental changes to operational practices, norms and strategies?

The first question closely follows the pattern of the second case in looking for alternative models of vehicle production (in niches – see p.59) that challenge the dominant regime. The second question, more closely mirrors the first case of the existing industry which, whilst more homogenous and conservative, is exploring alternatives.

Wells & Nieuwenhuis (2012) also raise an interesting point by implication: do 'failed transitions' receive sufficient interest in the literature? This is an issue that will be revisited later in the literature review when 'Transition Pathways' are evaluated.



## 2.3 Technology Transitions Literature

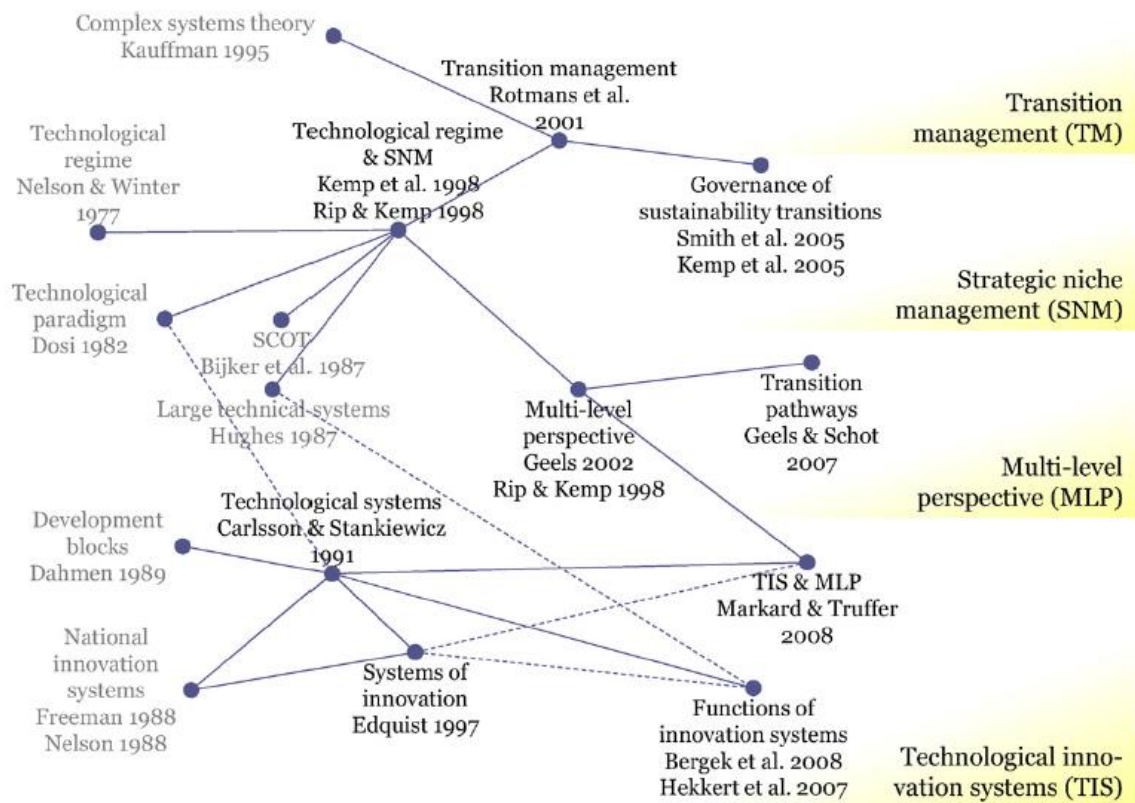
Whilst improvements in environmental efficiency can be achieved through incremental change “*much larger gains, however, are possible through system innovation or technological transitions*” (Elzen, Geels, Hoffman, & Green, 2002). The ‘transitions’ school of literature, as it has come to be known, undertakes to study the process of large scale systemic change in socio-technical systems.

Understanding transitions is an attempt to generalise about the process of socio-technical change through looking at technological transitions in different domains with different technologies. Common patterns are found when comparing transitions: “*Historians of technology and scholars of transition management advise us that socio-technical changes have a tendency to sneak up in disparate form and then to coalesce rapidly once the basic parameters for system change have fallen into place.*” (Cohen, 2006, p. 34). Inherent in this view, is that the development of technical innovations alone is insufficient to drive change, as these innovations are embedded in a social context. This social context comprises a diverse web of actors, all of whom interpret the process of innovation and respond to it in their own terms. The process of transition is a learning process (Park, 2013, p. 6558); this links back to the earlier discussion of ‘Wicked Problems’ [p.21] where Rittel & Webber (1973, pp. 166-167) set out that every intervention in the problem space alters the trajectory of the problem [creating path dependencies p.49]. The literature attempts to classify and make sense of this complexity, through understanding how the interaction between social actors and technologies gives shape to the direction and form of innovation. These processes take place on a range of levels set out in the multi-level perspective.

The transitions school is useful to interpret the process change at the macro level, and is a tool to understand how the shift will be made from conventional ICE vehicles to new ULEVs. Indeed the transitions literature already has some pedigree in being applied to the problems manifest in changing from one dominant mode of transport to another (Geels & Schot, 2005), [returned to on p. 69.]

In the next sections, the definition of the three elements of the multi-level perspective adopted in transitions thinking: the ‘landscape’, ‘regime’ and ‘niche’ are examined.

In the introduction to this chapter, reference was made to the Citation Network Analysis approach, which features as part of the methodology that was used to evaluate the business models literature in the early stages of this research. In a similar vein, Markard, Raven & Truffer (2012, p. 957) have provided an analysis which draws together many of the approaches, which are discussed in this next section. Focusing on transitions for sustainability, it draws together the different approaches of 'Transition Management', 'Strategic Niche Management' the 'Multi-level Perspective' and 'Technological Innovation Systems' which this next section evaluates and shows the relationship between pieces of key scholarship in the area.



**Figure 8 - Map of key contributions and core research strands in the field of sustainability transition studies. Copied from Markard, Raven & Truffer (2012)**

In addition, they provide bibliometric data on the 'most cited' works in the area, so in many respects, whilst the methodology used for compilation may be different, this analysis mirrors the citation network analysis conducted in the early stages of the "business models" literature (p.496).

### 2.3.1 Landscape

In transitions theory, 'landscape' refers to events occurring in the environment and society that impact upon the regime and niche levels but cannot be directly considered to be a part of them. The term is used as it has "*connotations of [...] hardness*" (Geels F. , 2005, p. 684), echoing the property of the landscape in transitions theory in that it cannot be directly shaped or changed by actors (Geels F. , 2005, p. 684). It serves as a backdrop for regime and niche level events. The landscape changes slowly (Verbong & Geels, 2007, p. 1026) but, by contrast, events are more dynamic at regime and niche levels.

With 'transitions' focus on socio-technical systems, the landscape necessarily encompasses elements of both 'society' and 'technology'. It can refer to social practices and norms, which become embedded. Geels (2004, p. 913) illustrates the hardness of what, on first sight, might appear 'soft' social principles, noting "*shared cultural beliefs, symbols and values are hard to deviate from.*" Furthermore, as well as using the *metaphor* to extend to the social elements, there is the *literal* physical landscape (Geels F. , 2004, p. 913) i.e. the spatial order of infrastructure, conurbations, industry and commerce.

There are a variety of concurrent changes and trends taking place at this level. Examples could include widespread social changes (Pel, 2012, p. 65) [citing trends such as individualisation, emancipation e.t.c.], changes in resource availability (Pel, 2012, p. 65) [citing the price and availability of oil as an example]. Occasionally, events can coalesce to produce a "landscape shock" (Verbong & Geels, 2007, p. 1027) prompting changes in the regime. An example of this could be the "oil shocks", where combinations of political and external factors create an exogenous context to the system to which the regime must adapt.

The introduction to this thesis, Chapter 1, sets out many environmental debates that 'frame' this study; in many cases, these discourses can be considered embedded in the "landscape" in which this study is set. There is also a "landscape" to the automotive industry, which is explored in the next chapter. Chapter 5 discusses further 'landscape' developments specific to the UK context.

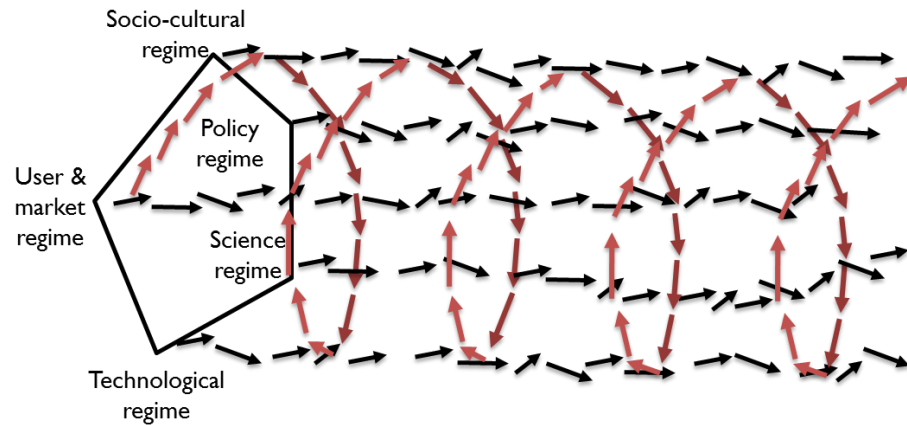
The landscape also impacts the other MLP levels. Verbong & Geels (2007, p.1031) had concluded that "*regime transformation [is] strongly influenced by external landscape developments*".

### 2.3.2 Regime

A regime is a socio-technical mechanism, which retains certain innovations causing them to become the dominant, stable design, whilst rejecting other potential innovations (Geels, 2002).

Dosi (1982) originated the idea of the 'technological paradigm' and 'technological trajectories'. In transitions theory, this idea has been subsumed into the idea of a 'technological regime' (Geels, 2004, p.911 cites Dosi, 1982). Dosi (1982, p.152) defines technologies as '*pieces of knowledge*' which are applied to problems and theories. Within this basket of knowledge are '*know-how, methods, procedures, experiences of success and failure*'. These could be codified into engineering standards or retained as tacit knowledge that the actors that create, modify and utilise those technologies within the regime. Furthermore, in addition to theoretical constructions of technology, there are the practical embodiments of that technology in tangible objects which represent the application of this knowledge. From this construct of technology, the idea of a '*technological paradigm*' is built, which Dosi (1982, p.152) defines as a '*model and a pattern of solution of specific technological problems based on selected principles derived from natural sciences and selected material technologies*'.

Geels (2002) contributed significantly to the evolution of transitions theory, by expanding the definition of regimes beyond that of the 'technical regime' to the much broader 'socio technical regime'. These comprised of those engaged in policy environments, supply chains, financial provision, consumers, educational institutions, in other words those social actors who contribute to the stability or otherwise of socio-technical regimes. Geels (2004, p. 911) notes that stable socio-technical configurations are comprised of different 'streams' of history, and each of these streams has its own communities of practice and actors. Geels (2004, p. 911) cites the work of Freeman and Louçã (2001) who defines science, technology, economy, politics and culture as five sub-systems of regimes. Each of these subsystems comprises its own regime. Freeman and Louçã (2001, p. 127) notes that each of these subsystems will have their own development line. This is illustrated overleaf in Figure 9 in a diagram from Geels (2004, p.912), who notes that in order to understand sociotechnical systems, consideration must be given to all of these different trajectories in the round.



**Figure 9 - Alignment of trajectories in different regimes Redrawn from Geels (2004, p. 912)**

In Geels' (2004, p.912) work, which featured the above (Figure 9) diagram, only the black lines were visible. The lines signify how the different regimes trajectories form an eventual alignment, despite different ideas, concepts, memes and technologies shaping their pathways. This relates to some fundamental ideas at the heart of transitions theory; Why are regimes dynamically stable? The innovation literature looks at questions of 'technology lock in' (See page 50). This concept is closely related to the concept of 'path dependency' (see page 49); which is to say future options are shaped by past choices within the regime. These concepts are allied to the notion of a 'technological' (and perhaps also scientific) regime. The *other* (user, socio-cultural, political) regimes will have their own trajectories that independently develop, but there will be interdependencies and influence between them. In later work, Geels (2011, p. 27) accounted for these regime interdependencies through the addition of the red "corkscrew" line in Figure 9.

Geels (2005, p. 86) ascribes the stability of regimes to the social norms, rules and procedures, both formal and informal, that govern the conduct of those groups. It is this '*semi-coherent web of rules*' which comprises the socio-technical regime. The stability of the regime arises out of how closely the actors within that regime adhere to the rules or how much '*alignment or tension*' there is with the rules (Geels F. W., 2005, p. 86). Vested interests within the regime will seek to maintain and prolong the incumbent regime (Rip & Kemp, 1998). These actors may have investments in technologies or social structures that benefit from the stability of the regime, so they will seek to reject change. This potentially proves a barrier to new innovation; sunk investments have been a barrier particularly to new innovations that can aid a transition to more sustainable socio-technical practices (Geels F. , 2010).

Translating these rules to the automotive context, it can be seen how these rules are not necessarily codified by laws and regulation, but also by the social and technical environments that are created. The infrastructures of mobility create rules for vehicles to adhere to in order to access this infrastructure. Here also, it is worth referring back to Urry's (2004) definition of the specific character of domination of the automobility system (p.22); whilst employing a different lexicon, this also refers to the factors that create regime stability. The stable nature of the regime is also highly dependent on regional context. Automobility regimes differ dramatically in different countries, by way of example, consider the difference in regime between developed, and developing countries (Wells P., 2001, p. 7).

Wells (2001, p. 6) notes that it is '*insufficiently appreciated*' the degree to which Western car markets and the technology regimes that support them are 'constructed'. In deconstructing what constitutes the automobility regime, Wells (2001, p. 7) lists the following:

- *Physical Infrastructure: (Roads, Car Parks, Shops e.t.c. suited to car use)*
- *Business Support Network (Car Dealerships, Repairs, Fuel, Roadside Rescue, Parts)*
- *Enforceable Regulatory Regime (Driver & Vehicle Testing, Traffic Control, Insurance, Policing)*
- *Cultural Attitudes (Driver / Pedestrian Behaviour, Propensity to Save / Borrow, Use of Credit to purchase goods)*

Linking back to Dosi's (1982, p.152) ideas of technology as knowledge, Kemp (1994, p. 1028) illustrates that the 'learning' or 'experience curve' provides one powerful explanation for the durability of regimes in industries heavily reliant on process or mass production, Dosi (1982) notes the [mainstream] car industry as one example. The implication of experience curves is that all other things being equal the labour input required for 'knowledge creation' per unit of output falls dramatically as volume increases (due in part to cumulative accretion of knowledge). This provides a huge disincentive to radical changes in practice; in other words new practices entail new knowledge and knowledge to reduce costs is only accrued through experiences.

So far, this section has largely covered the factors that promote stability in regimes, however, this thesis is interested in factors that shape and change regimes enabling them to transition. There are "*tensions in incumbent socio-technical regimes [which are] acknowledged to provide niches with development opportunities*" (Smith A. , 2007). It seems appropriate therefore to now look at the niche.

### 2.3.3 Niche

Geels (2011, p. 27) underscores the crucial role that niches play in transition by saying that niches are the “seeds for systemic change.

***Technological niches form the micro-level where radical novelties emerge. These novelties are initially unstable sociotechnical configurations with low performance. Hence, niches act as ‘incubation rooms’ protecting novelties against mainstream market selection (Schot, 1998; Kemp, Schot, & Hoogma, 1998) Niche-innovations are carried and developed by small networks of dedicated actors, often outsiders or fringe actors.***

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(Geels & Schot, 2007)

In the early stages of niche formation, groups work on new technologies in spaces that are protected from the mainstream market. In the very early stages of the formation of ‘niche’ actors, who believe that they stand to benefit from the merits of a new technology, there is promotion of the superior benefits of the novel features that technology offers (Park, 2013, p. 6559). These could be companies or commercial entities seeking to profit from niches, or they could be state actors who are encouraging niches for social or environmental purposes. Geels (2002) notes how niches provide spaces that are protected from the rules and selection processes of the regime.

Niches are challenging spaces for firms to work in as innovations may be incongruous with the demands of the regime because of a “mismatch with existing regime dimensions” (Geels F. W., 2011, p. 27). This could be because widespread consumer practices and culture do not yet support the niche, or because there is not sufficient regulatory support, or as a result of the lack of appropriate infrastructure (Geels F. W., 2011, p. 27). All of these could be said to presently apply to ULEVs to varying degrees.

Niches can be in research and development labs, technology incubators or protected spaces such as field-test trials. In the UK ULEV context, these protected spaces could be trial areas for EV rollout (Plugged In Places), hydrogen demonstrator projects (London Hydrogen Project) or applications for which new technologies possess specific advantages that render regime technologies unsuitable [e.g.

electric motors were chosen for milk floats due to their quietness in the early hours of the morning (Foreman-Peck, n.d)].

The niches exist at a level below the regime in the multi-level perspective. Rotmans & Loorbach (2010, p. 136) note that the structure of niches, as systems, in fact mirrors that of regimes, albeit in immature form. It too has '*rules, structure and culture*' but with less critical mass and potentially in a less coherent form than an established regime. Rotmans & Loorbach (2010, p. 136) refer to the concept of a niche-regime. A niche-regime is still imbued with the protective qualities of the niche, sheltering actors from the full selection processes of the dominant regime. The niche-regime, however, has some of the characteristics of the niche but in a smaller, emerging form. An alternative taxonomy is the 'empowered niche' (Rotmans & Loorbach, 2010, p. 136). What differentiates the niche-regime from a niche is that, through accretion of socio-technical actors and having been through learning processes, the niche-regime reaches the stage at which it has the potential to attack the established regime.

However, the niche is not always involved in a combative process with the regime (Geels & Schot, 2007), niches can also exist close to it. Rather than the pattern of 'overthrowing' the regime, the niche may simply be 'absorbed' (Rotmans & Loorbach, 2010, p. 137) into the existing regime effecting some sort of mutation or change in the process.

Another theme that occurs throughout both the sustainability (p.4) and innovation discourse (p.83) is the debate about the required speed of innovation and change. Geels (2002, p. 59) asserts that the speed of change is a function of the niches resource availability. This would seem intuitive, but, at the same time, it is perhaps a question as to what strategies under-resourced niches can employ to leverage their challenger advantage to the maximum. In some cases, the resources of niches can be artificially bolstered through regulation or funding. The process of nurturing niches for strategic purposes is known as Strategic Niche Management.



### 2.3.4 Strategic Niche Management

Strategic Niche Management is the process of nurturing novelty and innovation within a protected space. Strategic niche management “*surpasses a technological stalemate*” (Kemp R. 1994, p. 1043) by providing some sort of external stimulus to provoke niche innovations. Niches can be encouraged by firms, through creating a “skunk works” (Geels F. 2004, p. 912) or a “special projects unit” within a firm or by the state, by funding demonstrator projects. The literature on niche-innovation (Geels F. W., 2011, p. 28; Schot & Geels, 2008) also points to three approaches to niche-development:

1. The *vision* of what the niche seeks to achieve must be expressed clearly and articulated by the niche actors involved. These visions then act as a focal point for external funding, investment and further interest in developing the niche.
2. *Networks* build niche capability. Niches are often under-resourced (see p.60); in order to attract resources to the niche, social networks need to be constructed in order to grow the expertise and knowledge available to the niche. This results in growth of the physical, human and financial resources.
3. *Learning* within the niche needs to be encouraged, and the results of learning projects need to be articulated. Geels (2011, p. 28) explicitly includes “business models” in his learning points for niches, others are; “*technical design, market demand and user preferences, infrastructure requirements, organisational issues, policy instruments, symbolic meanings.*”

Strategically managed niches can therefore serve as “*building blocks for greater societal changes towards sustainable development*” (Schot & Geels, 2008, p. 539). Whilst Strategic Niche Management can be used as an approach for proactive interventions, (Mourik & Raven, 2006, p. 2) asserts it is more often used for retrospective analysis. Here, they acknowledge is a shortcoming and a missed opportunity.

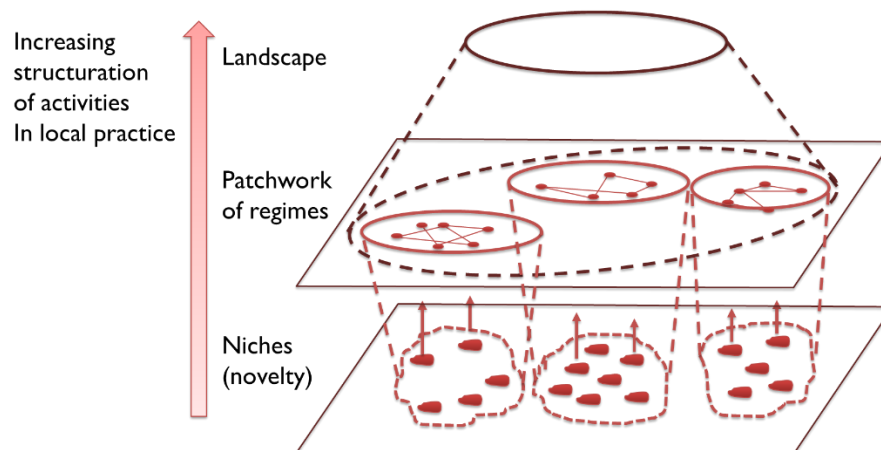
Subsequent scholarship has criticised an overly niche-focused approach which neglects paying attention to the regime and landscape levels.

### 2.3.5 The Multi-Level Perspective

Geels (2010, p. 495) notes the foundations of the Multi-Level Perspective of transitions theory in work on quasi-evolutionary theory conducted by a group of researchers based in Twente (Rip, A quasi-evolutionary model of technological development and a cognitive approach to technology policy., 1992).

Geels (2011, p. 26) describes the MLP as a ‘middle range theory’. Merton (1968, p. 5) describes these as “theories intermediate to the minor working hypotheses evolved in abundance during the day-by-day routine of research, and the all-inclusive speculations comprising a master conceptual scheme.” Boudon’s (1991) criteria are that middle range theory ‘explains’, ‘consolidates’, and ‘federates’ regular patterns in empirical data that would otherwise be unconnected, but at the same time it does not attempt to identify some ‘overarching independent variable’ or some ‘essential feature’ of the social structures under examination.

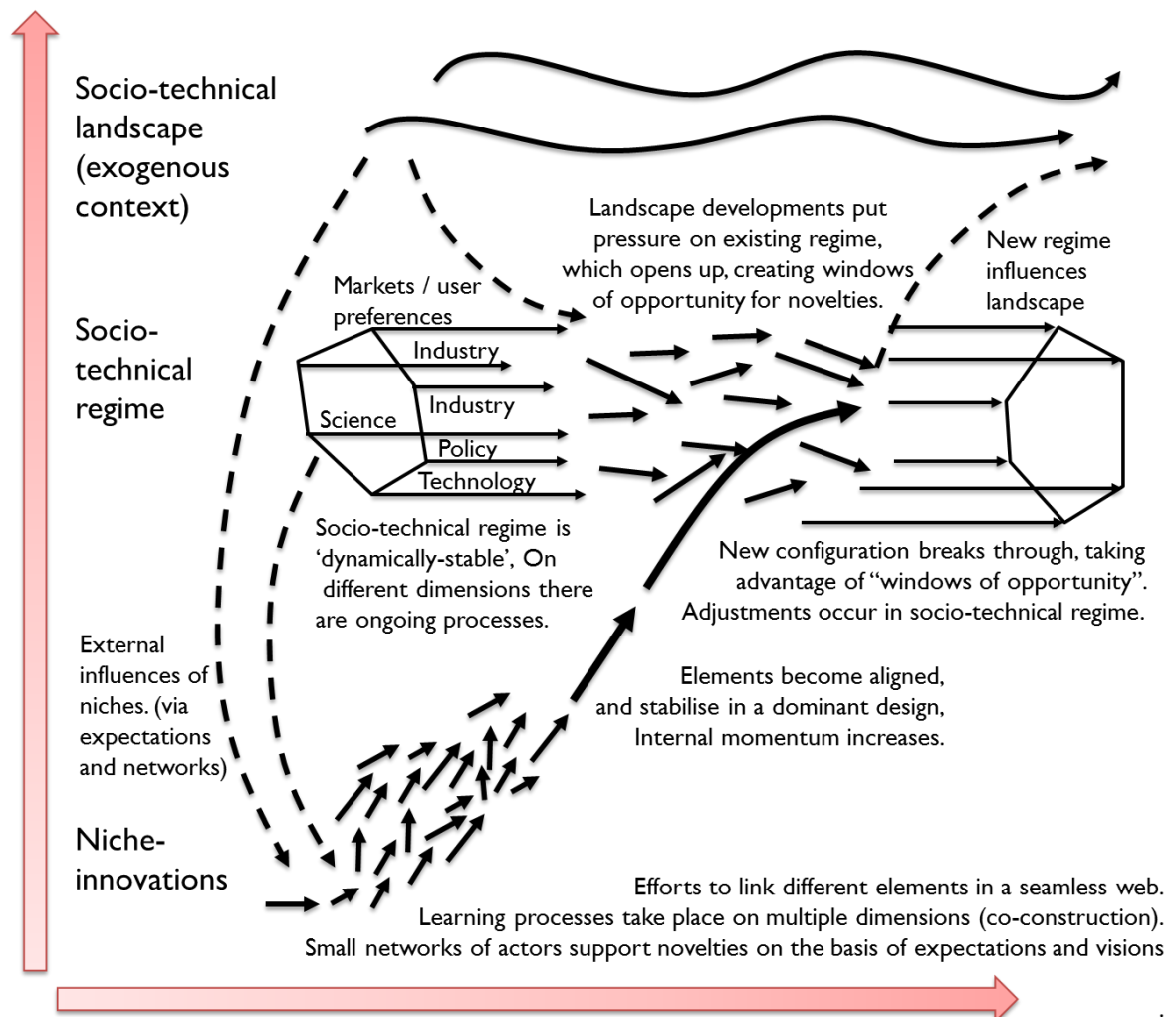
The multi-level perspective describes niches, regimes and the landscape as a “nested hierarchy” (Geels F. , 2005, p. 684). Niches are embedded within regimes, and regimes are in turn embedded in the landscape (Geels F. , 2005, p. 684). This is illustrated in Figure 10 below.



**Figure 10 - Multiple levels as a nested hierarchy (Geels F. , 2005, p. 684).**

Geels (2011, p. 29) notes that one key consideration of applying the MLP to problems is that simple notions of cause-and-effect become redundant; “There is no single ‘cause’ or driver. Instead, there are processes in multiple dimensions and at different levels which link up with, and reinforce, each other (‘circular

causality’).” The interactions between the levels are better explained by the following diagram which provides an alternate representation of the multi-level perspective:



**Figure 11 - Multi Level Perspective on Transitions redrawn from Geels (2011, p. 28)**

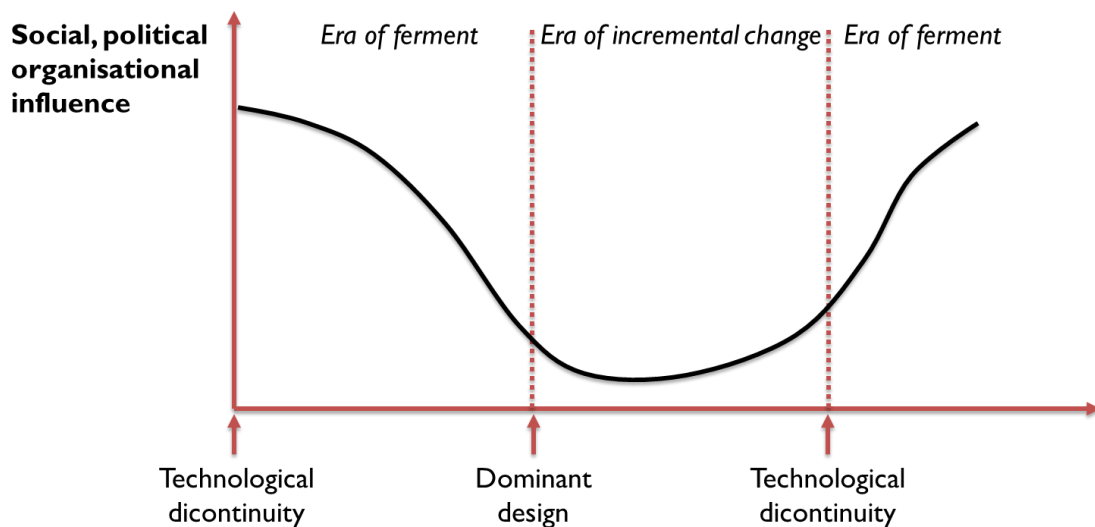
This thesis is interested in the interaction between new SME's with 'challenger products' and the offering of established TNC/MNC vehicle producers. The MLP captures this interaction; "Niches may be viewed as a micro-level phenomenon, interacting with the established regimes at the mesolevel, within a macro-landscape." (Geels & Kemp, 2007).

There are some criticisms of the MLP (Genus & Coles, 2008), However, the 'transitions literature regime' is also influenced by these challenger 'academic niches' and Geels & Schot (2007) and Geels (2011) have responded to these and others by refining and clarifying the MLP framework.

### 2.3.6 Transitions Pathways

The fourth research theme (p.40) focuses explicitly on transitions pathways. Within the cases, evidence of transition pathways is sought and in doing so the mechanisms are compared with the existing work on transitions pathways in order to develop this field in the conclusions (see p.388).

In earlier discussions about the nature of change and continuity, the fundamental nature of innovation and socio-technical stability was discussed. Geels (2010, p. 505) points to periods of incremental change, where one design dominates, as being a period during which 'rational choice' prevails. During periods of discontinuity where certain configurations fail to dominate, the importance of exogenous social, political and organisational narratives become more important in shaping the 'era of ferment'. This fits with the ideas advanced by Christensen (1997) about innovation, which will be examined on page 84; however, what the transitions framework adds to these ideas is the importance of social and political agency in shaping the changing regime. This also resonates with Dolfsma & Leydesdorff's (2009) concept of a third selective force being a component of breaking away from lock-in.



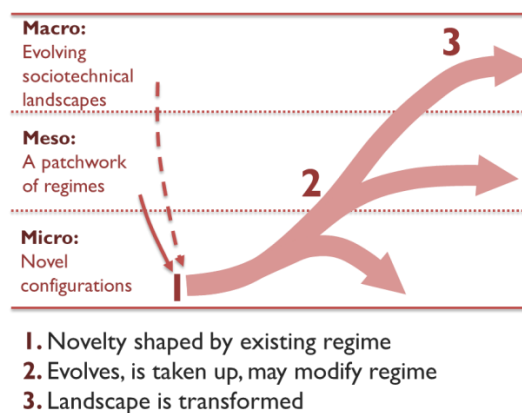
**Figure 12 - Degrees of social shaping during transitions and stable periods  
Redrawn from Tushman & Rosenkopf (1992) as cited by Geels (2010, p. 506)**

One of the perspectives that guides MLP and SNM is that, through an appreciation of the frameworks of transition, it is possible to manage the process of transition and even go beyond this to promote

and encourage the process of transition (Kemp & van Lente, 2013, p. 115) [citing (Rotmans, Kemp, & van Asselt, 2001) & (Rotmans J. L., 2009)]. In order to achieve this, it is necessary to understand the pathways of transition.

Returning to the MLP, scholars of transitions have studied links between the niches, regimes and landscape in detail. Background changes in the landscape impact on both the regime and the niche levels, in that, whilst over long periods of time the regime can influence the landscape in a more direct, responsive manner, the configuration of the regime impacts upon the niche.

Avelino, Bressers & Kemp (2012, p. 36) set out an alternative representation of the multi-level model of transition, which takes the lessons of the MLP but presents the relationship between the different levels in a simpler way. This is set out below in Figure 13. This study particularly focuses on elements 1 & 2 of the process. However, whilst examining the interaction between Micro & Meso levels, there is a mindfulness of the need for a wider Macro level sustainability transition (as set out in Chapter 1).



**Figure 13 - Multi-level model of innovation and transformation (Avelino, Bressers, & Kemp, 2012, p. 36)**

Of particular interest is how niches transfer their innovation payload, to the mainstream:

***Niches emerge and cluster, and by empowering a niche cluster, a niche regime unfolds; the niche-regime becomes more powerful whereas the regime is weakening, and in the end, the niche-regime takes over the regime that is transformed.***

(Rotmans & Loorbach, 2010, p. 136)

Geels & Schot (2007, p. 399) proposed a typology of four different ‘transition pathways’: ‘transformation’, ‘reconfiguration’, ‘technological substitution’ and ‘de-alignment and re-alignment’. Papachristos, Sofianos & Adamides (2013) propose a fifth addition to this list of transition pathways – that of ‘emergence’.

<b>Transition Pathway</b>	<b>Description of Transition Pathway</b>
<b>Transformation</b>	<i>If there is moderate landscape pressure (‘disruptive change’) at a moment when niche-innovations have not yet been sufficiently developed, then regime actors will respond by modifying the direction of development paths and innovation activities.</i> Geels & Schot (2007, p.406)
<b>Reconfiguration</b>	<i>Symbiotic innovations, which developed in niches, are initially adopted in the regime to solve local problems. They subsequently trigger further adjustments in the basic architecture of the regime.</i> Geels & Schot (2007, p.411)
<b>Technological Substitution</b>	<i>If there is much landscape pressure (‘specific shock’, ‘avalanche change’, ‘disruptive change’) at a moment when niche-innovations have developed sufficiently, the latter will break through and replace the existing regime.</i> Geels & Schot (2007, p.409)
<b>De-alignment and Re-Alignment</b>	<i>If landscape change is divergent, large and sudden (‘avalanche change’), then increasing regime problems may cause regime actors to lose faith. This leads to de-alignment and erosion of the regime. If niche-innovations are not sufficiently developed, then there is no clear substitute. This creates space for the emergence of multiple niche-innovations that co-exist and compete for attention and resources. Eventually, one niche-innovation becomes dominant, forming the core for re-alignment of a new regime.</i> Geels & Schot (2007, p.408)
<b>System Emergence</b>	<i>When two or more stable regimes face landscape and/or internal pressures, due to limiting returns to development and/or intense competition, it might be impossible to look for solutions in internal niches that will provide for increasing, pending or diversifying societal needs. As long as the regimes serve some societal function, they will not disintegrate (as in the dealignment–realignment transition pathway). Then, contingent on the nature of the technologies that each system harbours, it is possible for them to “vent pressure outwards” and for a new system to grow on the fringes of, and be shaped out of the interactions of existing systems. The degree to which the new system is compatible with aspects of its ‘parent’ systems depends on the degree to which it provides solutions to the problems they face.</i> Papachristos, Sofianos & Adamides (2013)

**Table 6 - Descriptions of a range of ‘transition pathways’**

Schot & Geels (2007, p.406) also have a ‘reproduction path’ of what happens “*If there is no external landscape pressure [...] then the regime remains dynamically stable and will reproduce itself.*”. However, does that fully explain all failures of transition? Are there perhaps instances when, for whatever reasons, landscape pressures do not manage to prompt a transition, but a transition is still needed?

### 2.3.7 Transition Failures

What perhaps is missing from the academic literature is a typology of ‘non-transition’ pathways. There are plenty of instances of where socio-technical regimes have endured beyond the point at which either a) there could be considered better alternatives or b) the regimes are unsustainable, and through their unsustainability begin to create problems for society.

What strategies do incumbent regimes use to sustain their socio-technical configuration beyond sustainability? How do incumbent regimes suppress and resist insurgent regimes? Is this process an active resistance to change or a benign systemic failure? The transitions literature is, by its very nature, biased towards the examination of positive transitions. What if these don’t take place? It has been argued that there is a publication bias in academia towards positive results [although arguably these arguments are strongest in the field of medicine (Dickerson, 1990; Higgins & Green, 2008; Fanelli, 2010; Johnson & Dickerson, 2007)]. This ties in to issues of ‘publish or perish’ culture in academia generally. No one wants to know about the medicine that didn’t work, the chemicals that didn’t react, the social groups that weren’t in some way deviant or the archaeological dig sites where nothing was discovered. The public would not have heard about Edison’s 99 attempts were it not for the one positive result. The transitions that didn’t occur aren’t examined, and perhaps they should be, and in more detail and applying the same systemic rigour, definition and classification as has been applied to successful transitions.

Wells & Nieuwenhuis (2012) have already identified the ‘transition failure’ in the automotive industry in their work, so it is not to say that there is not some scholarship on the issue. Others have examined ‘barriers to transition’ (Farla, Alkameda, & Suurs, 2010; Verbong & Geels, 2008; Struben & Sterman, 2008), however, there is not the same level of interest, the same breadth of case studies or the same level of activity that results in Geels & Schot’s (2007) typology of transition pathways. It does not appear at present that there is a ‘typology of stagnation’ and where the lack of transition ‘causes harm’. There is a need for this type of analysis.

This issue will be revisited when the fourth research theme is considered in the conclusions (p.388).

### 2.3.8 Transitions to Sustainability

The existing transitions literature addresses the challenges of ‘technology transitions’ more generically. Unsurprisingly, because many of the challenges that the move to sustainability requires us to address involves the confluence of ‘society’ and ‘technological change’, the transitions literature has received much interest in the domain of sustainability. Markard, Raven & Truffer (2012, p. 955) assert that around 60-100 papers annually are published on the theme of ‘sustainability transitions’. Their work tracks the evolution of the literature that is central to the understanding of sustainability transitions. There are unifying factors that differentiate analysis of sustainability transitions from the more general study of socio-technical transitions. The following two definitions provide clarity:

***Transitions towards sustainability have some special characteristics that make them different, in certain respects, from many (though not all) historical transitions. First, sustainability transitions are goal-oriented or ‘purposive’ (Smith et al., 2005) in the sense of addressing persistent environmental problems, whereas many historical transitions were ‘emergent’ (e.g. entrepreneurs exploring commercial opportunities related to new technologies).***

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(Geels F. W., 2011, p. 25)

***Sustainability transitions are long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption. One particularity of sustainability transitions is that guidance and governance often play a particular role.***

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(Markard, Raven, & Truffer, 2012, p. 956)

The one theme that appears in these two definitions is the notion of a goal that drives purposive transformation, that there is a goal to the transition. By implication in Geels (2011) and more explicitly in Markard, Raven & Truffer (2012), there is the notion of some external stimulus guiding the transition. This feeds into the recurring theme of regulation mediating between producers and consumers (examined later on p. 77).

Whilst this study notes regulation and policy instruments as a driver (and provides an account of the policy environment that forms the landscape to this study in Chapter 5), the focus is on the process



of transition itself, and not on the external policy drivers of transition. This study focuses on the “emergent” transition that is generated through enterprises spotting opportunities to be entrepreneurial and grow their businesses. This was underscored by the introduction to a Special edition of the journal “Technological Forecasting & Social Change”, (Farla, Markard, Raven, & Coenen, 2012) which focused on the role of actors in sustainability transitions. It is the actors that drive change through strategy and vision, (2012, p. 992); furthermore, different actor groups articulate and lobby for various positions depending on their interests. In particular, Farla, Markard, Raven & Coenen (2012, p. 995) engage with actors within firms, and note that there are firms that can be *far-reaching* in their vision for sustainability, positively seeking to create a context for innovation. They note that these actors can “*deliberately create positive externalities and invite others to join an emerging field to gain momentum against established technologies*”; however, they also make reference to Penna & Geels (2012) as a case that is illustrative of the opposite. Here shows how “*incumbent firms can be less driven by their own innovation agenda but only reluctantly engage in a ‘green’ innovation agenda in response to pressures exerted by social movement actors and policymakers*” (Farla, Markard, Raven, & Coenen, 2012, p. 995).

What is important about this perspective on sustainability transitions, when relating it to the Business Model Canvas (evaluated later on p.100), is that the canvas as a business model ontology recognises the agency of a wide range of actors: on the one side, there are the actors that create value through **KEY PARTNERS**; indeed actors themselves can even be a **KEY RESOURCE** in terms of human capital or knowledge. Then on the other hand, the value is captured through the **CUSTOMER RELATIONSHIP** and the **CUSTOMER SEGMENTS** that are started. However, on its own, whilst the canvas captures both actors within the firm and other actors that are peripheral to the firm (in terms of key partners and customers), there are actors outside of the firm(s) and in different regimes who influence the firm and the context in which the firm works. It is for this reason that this thesis situates the Business Model within the wider framework of transitions theory (illustrated on page 119).

One of the criticisms Farla, Markard, Raven & Coenen (2012, p. 995) make of other approaches examining a move towards more sustainable practices is that some prize the agency of individual

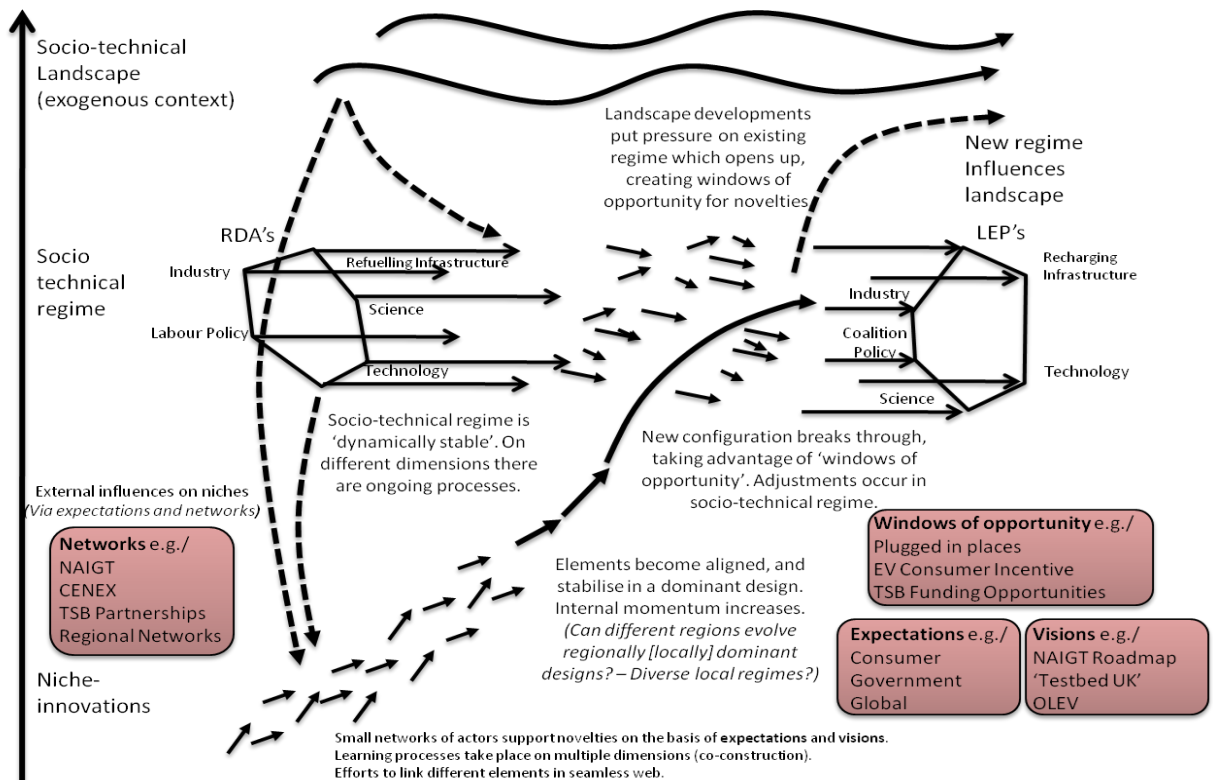
actors, ignoring the broader implications of collective agency, interactions between actors, and the wider actor networks engaged in sustainable transitions. Farla, Markard, Raven & Coenen (2012, p. 995) highlight the roles of actors outside the firm, and list a range of literature discussing the role of other actors in transitions: “*social movements, civil society and consumers (Penna & Geels, 2012), experts and research organizations (Musiolika, Markard, & Hekkert, 2012), (Bakker, van Lente, & Meeus, 2012), (Konrad, Markard, Ruef, & Truffer, 2012) and individual actors that try to change a system from within (Schuitmaker, 2012).*”.

Another regime that impacts heavily on sustainable transition pathways is the political regime. Meadowcroft (2011, p. 70) has noted that politics is an often neglected dimension to sustainability transitions. Studies often engage with the social and technical but fail to explore the political factors that shape both the landscape and regime. Later, the methodology is considered, which places the two cases that form the empirical core of this research within a “context” (p.187); a context which contains elements of both landscape and other regimes that support the present UK vehicle manufacturing socio-technical regime. Also significant in the literature is the nature of the networks that have formed to support actors in the sustainable transition (Musiolika, Markard, & Hekkert, 2012, p. 1047). Some of these UK networks, (e.g. RDAs) have been swept away as a result of political regime transition.

The focus of this research is on the firm i.e. the business model of the actors seeking to introduce vehicles is the key emphasis of the empirical material. That said, all of the cases are considered embedded in the UK national context, and, whilst there is a distinct regional dimension (Harper & Wells, 2012) [and overleaf] to how different localities have approached early-market ULEV introduction [and competing visions and expectations (Bakker, van Lente, & Meeus, 2012, p. 1059)], many of the actors and networks at national level are common to all of the cases. Furthermore, the national level is a suitably tight boundary that the ‘*collective expectation*’ of technologies which acts as a co-ordinating and signalling force to actors and networks (Konrad, Markard, Ruef, & Truffer, 2012, p. 1096) is common to all of the embedded cases. Actors and networks that are extrinsic to the firm are considered in Chapter 5 which considers those contextual elements common to all the cases.

### 2.3.9 The Multi-Level Perspective in the UK ULEV Transition Context

Harper & Wells (2012) have already applied the context of the UK ULEVs transition to the multi-level perspective. Of course, some of the elements annotated on the final configuration of the regime may not yet prove to be durable. Will Coalition policy, LEPs etc. endure? It is uncertain, but at this stage, the model is representative of some of the recent changes to the regime as represented in the literature. Chapter 5 will expand upon many of the points in Figure 14 in greater detail. What is particularly interesting about the UK context is the diversity of different options being pursued. The UK Motor Industry is marked by an incredible diversity of different actors, with many different visions and expectations being articulated.



**Figure 14 - The Transitions Framework as Applied to UK ULEVs Transition**  
 Reprinted from Harper & Wells (2012), originally adapted from Geels (2002)

Context (Chapter 5 p.210) informs what is happening within some of the regimes outside of the industry at the meso-level, whilst the cases and embedded sub-cases expose what is happening at the micro-level of the firm's business model. In aggregate these provide cases insight into the dominant industry regime, and those smaller firms working within niches challenging the regime.

### 2.3.9 Sustainable Mobility & The Transitions Perspective

A wide range of authors have deployed the transitions literature to challenges of sustainable mobility. Table 7 presents a range of cases reviewed by this literature. The transitions perspective and MLP framework has been used to interpret a range of cases in a range of different regional and national context. The prior application of the transitions framework in this manner to this type of problem validates the approach taken in this thesis. Furthermore, insight from some of these cases is used to inform the conclusions of the thesis.

<b>Author[s], (Date)</b>	<b>Domain of Application</b>	<b>Region of Application</b>
Szejnwald Brown, Vergragt, Green & Berchicci (2006)	Human Powered Vehicles	Netherlands
(Nykvist & Whitmarsh, 2008)	Niche Development	UK, Sweden
Cohen (2009)	Aeromobility	United States
Farla, Alkameda & Suurs (2010)	Hybrids, Biofuels, Natural Gas, Hydrogen	Netherlands
Orsato, Dijk, Kemp & Yarime (2012)	Electric Vehicles	International
Ehret & Dignum (2012)	Hydrogen, Fuel Cells	Germany
Pel, Teisman & Boons (2012)	Traffic Information Systems	Netherlands
Lyons, Jain, Mitchell & May (2012)	Intelligent Transport Systems	International – UK, US
Harman, Veeneman & Harman (2012)	Public Transport	UK, Netherlands
Park (2013)	Hydrogen, Fuel Cells	UK, South Korea

**Table 7 - Sustainable Mobility Cases Applying the Transition Literature**

The table above illustrates a strong European focus to the literature, particularly in the Netherlands, where the transitions theory originates from. In this context, due to a range of efforts, transitions theory has been applied as a tool, not only for retrospective analysis of transitions, but also for the ongoing stimulation of and management of socio-technical transitions.

## 2.4 Innovation & Technology Management Literature

***Innovation is not a single action but a total process of interrelated sub processes. It is not just the conception of a new idea, nor the invention of a new device, nor the development of a new market. The process is all these things acting in an integrated fashion.***

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Myers and Marquis (1969) definition of innovation in Trott (2005, p. 15)

Scholars of innovation seek to understand the innovation process, how it occurs and the diffusion of innovations through society. At the heart of this is the notion that understanding will lead to a better insight, effective management and faster and more frequent innovation. Innovation is of interest to the firm, as it can be a route to improved competitive advantage. Nidumolu, Prahalad & Rangaswami (2009, p. 57) note sustainable innovation has already started to shape and ‘*transform the competitive landscape*’.

To society, sustainable innovation has the potential to improve the social, environmental and, ultimately, economic sustainability of enterprises. Indeed, Nidumolu, Prahalad & Rangaswami (2009, p. 57) assert that “*the quest for sustainability can unearth a mother lode of organizational and technological innovations that yield both top-line and bottom-line returns.*” The motor vehicle industry can be viewed as a microcosm of any number of technology sectors that are facing the challenge of introducing new technologies, methods and products. In terms of ULEVs, there has been a great deal of discussion within the motor vehicle industry, with many concept and prototype vehicles being created and, more recently, some production vehicles beginning to enter the marketplace. However, low market penetration and poor uptake has precluded any genuine “*transformation of the competitive landscape*”. That is not, however, to say that drivers for sustainability and new innovations will not transform the industry in the future. Perhaps a firm that can ‘*innovate differently*’ will transform the industry in much the same way as Japanisation and the Toyota Production System defined a whole era of innovation.

In the preface to ‘Diffusion of Innovation’, Rogers (1962) notes that the first edition of the book was published in 1962, at which time there were 405 publications on the topic; by 2003, he estimated this number to be closer to 5,200 and growing apace at a rate of around 120 publications per year. Given this context, this thesis can only hope to lightly touch on the literature here.

### 2.4.1 The Innovation Process

Rothwell (1994) characterises the innovation process through five different generations of development. The ‘1<sup>st</sup> Generation’ Innovation Process being the predominant view on innovation from the 1950’s to the mid 1960’s. This is the ‘technology push’ view, which contrasts with the ‘market pull’ view (2<sup>nd</sup> Generation Innovation Process), which rose to prominence in the mid 1960’s-early 1970’s.

This simple characterisation of the innovation process is as a linear model, with “new technology” at one end and “the market” at the other. This model is known as the “technology push – demand pull” model” (Chidambar & Kon, 1993, p. 1). However, linear models of innovation are problematic. Whitmarsh & Köhler (2010, p. 438) note that, in formulating policy for the environment, linear models are inappropriate as there “...is no guarantee that R&D investment will result in technological breakthrough, nor that consumers will accept proposed policies...”. These concepts are seductively simple yet a fuller understanding of the process has necessitated more complex models of the innovation process.

The 3<sup>rd</sup> generation innovation process arose as a response to the conditions of the time, which Rothwell (1994, p. 9) characterises as a “*period marked by high rates of inflation and demand saturation (stagflation) in which supply capacity generally outstripped demand, and by growing structural unemployment.*” Furthermore, with recognition of two major oil crises and a decade of severe resource constraint, there is the introduction of ideas that innovation can be used to make better use of resources. Furthermore, the ‘technology push’ and ‘market pull’ models of innovation became contextualised as “*extreme and atypical examples of a more general process of interaction between, on the one hand, technological capabilities and, on the other, market needs*” (Rothwell, 1994, p. 9). The third generation model of innovation retains much of the linearity of earlier models but with enhanced communication and an emphasis that societal needs also moderated and shaped the innovation process (Rothwell, 1994, p. 10). This model of innovation was to endure until the early 1980’s.

With the economic recovery of the early 1980’s came a new form of innovation model (4<sup>th</sup> generation); one that recognised that certain activities, such as marketing, research and development, product development, production engineering, parts development by suppliers and manufacturers were ones

that should occur concurrently, with joint meetings between the managers responsible for all of these functions. This model of innovation is tied in with the growing recognition that, at the time, the methods and practices of Japanese manufacturers differed from those in the West. The unique competitive advantage of the Japanese came not only from product imitation, 'Just-In-Time' and an emphasis on quality in manufacturing procedures (Rothwell, 1994, p. 11), but also from a unique approach to innovation; working on processes concurrently and in parallel. Furthermore, those outside the company were brought into the process of innovation integrating external suppliers and firms into the innovation process. The "*Japanisation*" of the motor industry is examined from p.129.

One of the features that defines 5<sup>th</sup> generation approaches to innovation is the enablement of information and communication technologies. Many characterise 5<sup>th</sup> generation innovation processes as 'networked' with 'integrated systems' (Galankis, 2006, p. 1224; Nobelius, 2004, p. 370), with tighter integration between functional units through enhanced communication and an intensification of the speed of innovation through the deployment of novel ICT based management processes.

One of the more recent concepts to enter the innovation literature is the "Open Innovation" model (Chesbrough H. W., 2005; Chesbrough, Vanhaverbeke, & West, 2008). Open Innovation has been described as the 6<sup>th</sup> generation of innovation model, building upon Rothwell's (1994) five generations of innovation. Not all subscribe to the view that it is a new approach; Trott & Hartman (2009) describe it as 'old wine in new bottles', citing earlier descriptions of 'networked innovation' by Rothwell & Zegfeld (1985). What is clear though is that, whether the concept is old or new, the explosion in communication and collaboration opportunities afforded by the internet make sharing and collaboratively developing technology easier than ever. Open innovation changes the relationship between "insurgents" and "incumbents". It may be that if a product is not aligned with the firm's core business model, it is spun out into a separate venture. Furthermore, with more knowledge in the public domain, insurgents can overcome some of the barriers to entry, as technologies that were once proprietary become accessible to wider communities. Local Motors (p.158) is an example of one firm leveraging this approach to innovation, with 'Riversimple' (p.349) being another.

## 2.4.2 Innovation for Sustainability

In evaluating sustainability as a driver of innovation, Nidumolu, Prahalad & Rangaswami (2009, p. 57) identify a five-stage process, with each stage outlining a distinct process of change which enterprises on the 'journey to sustainability' go through. The first stage focuses around viewing environmental compliance as an opportunity rather than a threat. As a company's sustainability awareness evolves, they go on to look at making their value chains more sustainable: the second stage. This focus on exogenous actors then shifts to an inward focus in the third stage, where companies start designing more sustainable products and services within the firm. After this the focus then turns to developing business models (the fourth stage of the process). The final stage of the process involves creating "next practice" platforms.

The first two stages are relatively straightforward and self-explanatory. For the third stage, the development of new products and services for sustainability falls within the realms of "eco-innovation". Whilst the shortcomings of the simple linear models of innovation have already been discussed (p. 74), they are elegant in their simplicity and serve as a useful staging post to understand eco-innovation, as illustrated in Figure 15 below.

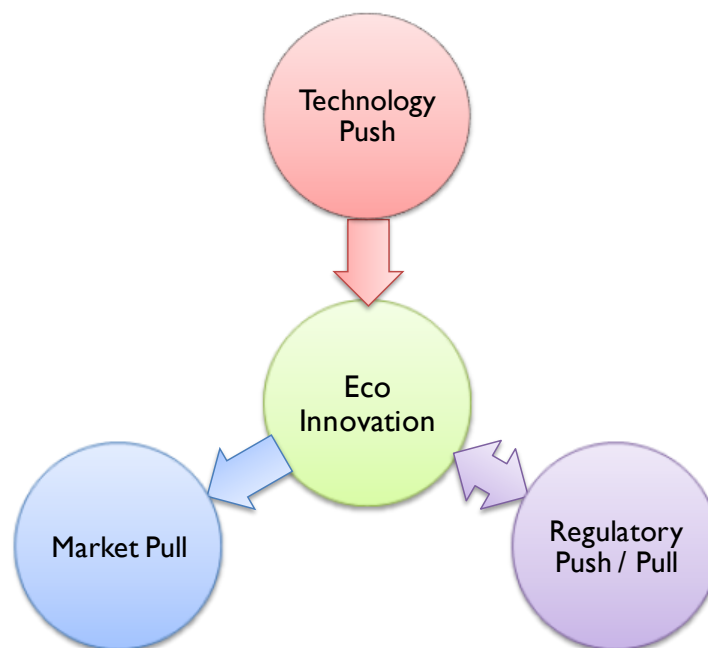


Figure 15 - Eco-innovation drivers (Rennings, 2000)



Here, in addition to the factors of “technology push” and “market pull” already explored, the additional mediating factor of “regulatory push-pull” can be seen. Returning to the first two factors, innovations might arise as a result of a new type of green technology being developed in an engineering or scientific context, with this pure research then translating into products. Alternatively, there may be consumer pressure for greener products or services with the industry then responding to these demands by developing alternatives. In the absence of significant consumer pressure, it is regulation that acts as a driver for eco-innovation. Regulations act to push the development of new technologies by setting tighter environmental standards, and may, in addition, act as a “pull” for new technologies by creating market incentives and subsidies for technology development. Later in examining the case study context, some of the regulatory push-pull factors in the UK regime will be examined (p.251).

### 2.4.3 Eco Innovation In Niches

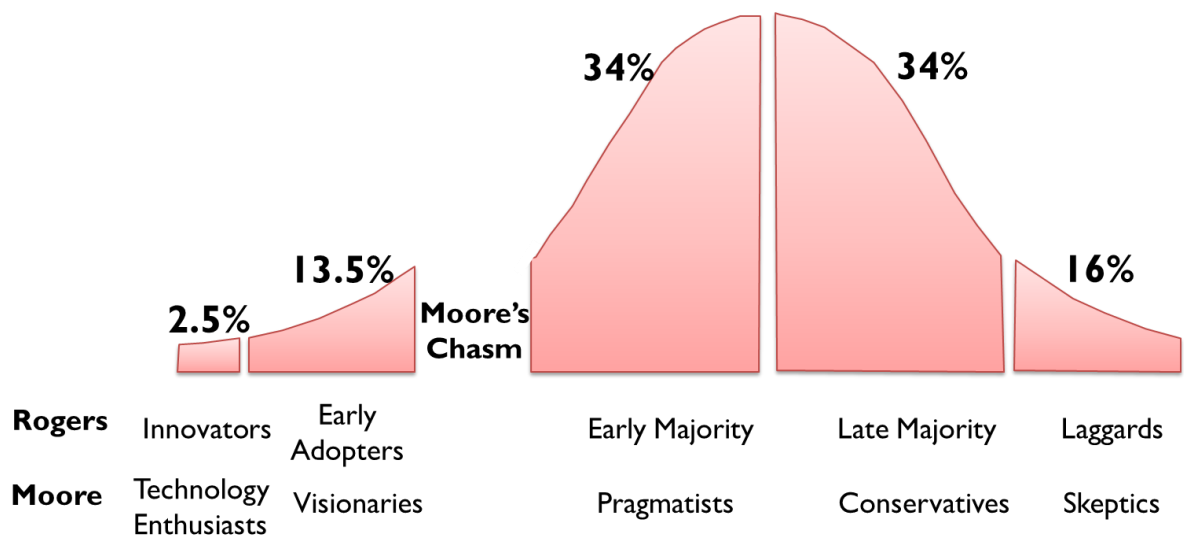
Linking some of the themes that have been previously discussed, a regulatory force can act as a driver for eco-innovation. Wide scale deployment of new innovations, however, is politically risky for policy makers, especially when there is a high degree of technological risk and uncertainty (**pError! Bookmark not defined.**).

For this reason approaches, such as Strategic Niche Management (p.59), allow the regulatory push-pull force to trial new innovations in projects for which there is a low risk. Politically, this carries a lower risk than widespread deployment of technologies which may not be at a stage of market readiness. This does, however, raise interesting questions from a business model perspective. If the businesses are operating in a protected space, with regulatory incentives and controls, the business models that are employed may be relatively immature and unsuited to widespread deployment? How will these models change with the process of transition and widespread deployment? These questions will be revisited later (on p.104 onwards).

These arguments are related to questions of the study of technology adoption and how innovations diffuse through society. The next section examines this dimension of the innovation literature.

## 2.4.4 Technology Adoption

An alternative approach that has been used to understand how innovations diffuse into the mainstream is the 'technology adoption lifecycle model'. This approach was originated by Rogers (1962) and has been expanded by Moore (1991). Rogers' original model considered the lifecycle of innovation and the percentage of users that adopt the innovation at each stage of its lifecycle. The curve is bell-shaped and divided into different customer segments. Moore (1991) modified this curve adding that the hardest transition was between the group of consumers that constituted the 'early market' and the 'late market'. These are parallels between the early market and 'niches', with innovators, early adopters, technology enthusiasts and visionaries being some of the customer segments willing to protect and nurture innovation in the early stages. The late market follows 'regime' practices, only purchasing innovations once they become established. It seems surprising that the link between these two understandings of innovation has not been well codified in the literature.



**Figure 16 - Technology Adoption Lifecycle Model based on Rogers (1962) revised y Moore (1991)**

It is straightforward to understand why the risks at early stages of innovation are high; investment in new product development is expensive and does not yield returns until products begin to penetrate the market. Figure 17 overleaf shows why the 'chasm', as articulated by Moore (1991), is a particularly challenging period for businesses; not only trying to penetrate new markets, but doing so at a time when the business may be financially challenged trying to recover development expenditure.

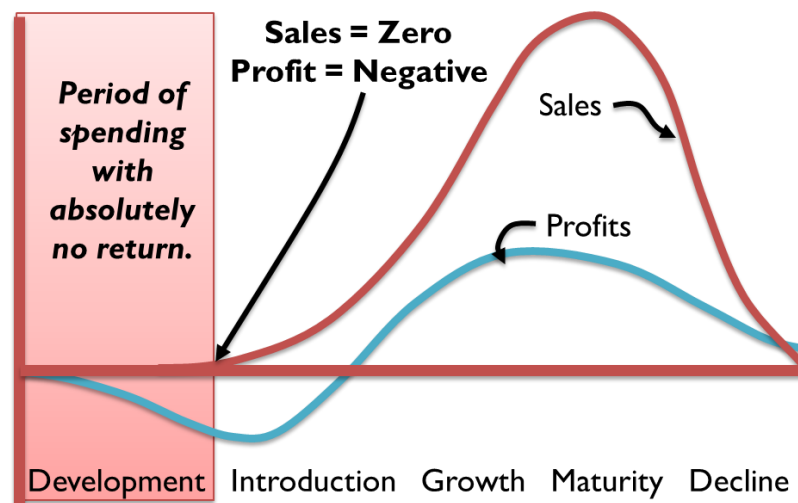


Figure 17 - Product Lifecycle: Sales & Profits

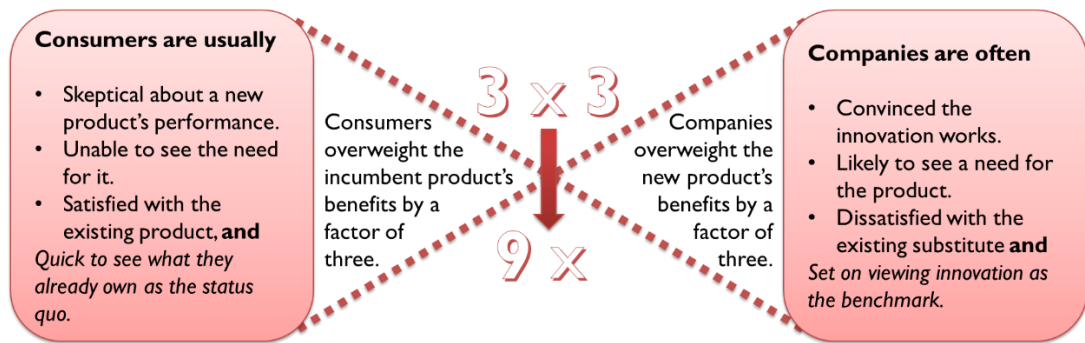
An alternative view of why incumbents do not adopt innovations is advanced by Christensen (1997) who interprets innovation in different terms. Where the Rogers (1962) and Moore (1991) models of innovation focus on consumer readiness to accept new technologies, Christensen (1997) instead focuses on the technologies readiness to meet the performance expectations of the average user.

Consumers may be ready and receptive to new technologies. However, if those technologies do not meet consumer expectations, they will fail. Here, Gourville (2006) highlights that the benchmarks consumers will use to judge a new technology is the technology solutions they presently employ.

***“First, people evaluate the attractiveness of an alternative based not on its objective, or actual, value but on its subjective, or perceived, value. Second, consumers evaluate new products or investments relative to a reference point, usually the products they already own or consume. Third, people view any improvements relative to this reference point as gains and treat all shortcomings as losses. Fourth, and most important, losses have a far greater impact on people than similarly sized gains, a phenomenon that Kahneman and Tversky called “loss aversion.”***

(Gourville, 2006)

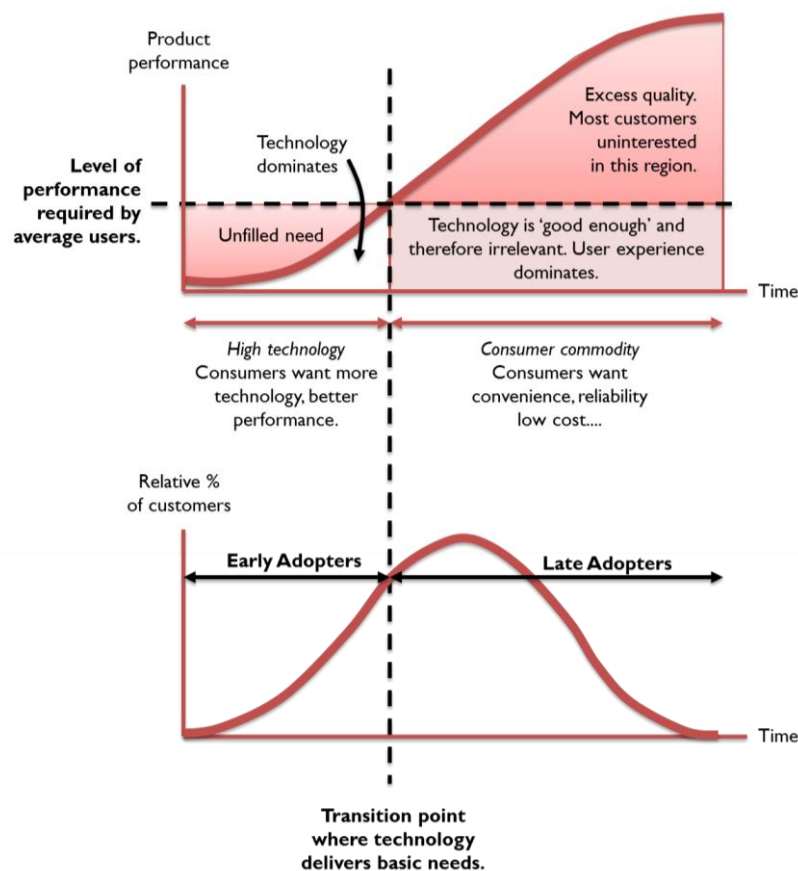
Gourville (2006) terms this dissonance between consumer satisfaction with their existing product (despite its possible shortcomings) and companies’ overestimation of the abilities of their new product the “9x” effect. It brings together the subtleties of these two slightly different perspectives.



There's a fundamental problem for companies that want consumers to embrace innovations: While developers are already sold on their products and see them as essential, consumers are reluctant to part with what they have. This conflict results in a mismatch of nine to one between what innovators believe consumers want and what consumers truly desire.

**Figure 18 - The 9x Effect (Gourville, 2006)**

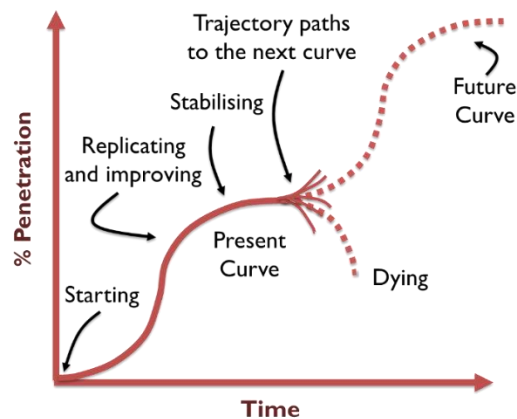
This association is also reaffirmed by Treloar (1999, p. 252) who restates arguments by Norman, (1998) that the 'Technology Adoption Lifecycle Curve' and Christensen's (1997) perspective are, both stating the same fundamental concept; that it is at the point that technology becomes "good enough", through the process of innovation, that the transition from the early market to the late market occurs.



**Figure 19 - Moving from high technology to consumer commodity. Image redrawn from Norman (1998) cited in Treloar (1999, p. 252). Norman's (1998) work, draws on (Christensen, 1997)**

The early market (what might be called a niche market) is receptive to new technology and can sacrifice some performance in exchange for leading with innovation. Once the technology becomes “good enough” then the late market will respond with purchases. The performance level of technology may continue to improve; however, this improvement in performance surpasses what is required by the majority of consumers. Perhaps it is this point of transition where the market moves from being in a “niche” to a “niche-regime” or even a regime?

In Figure 19, the ‘S Curve’ is introduced but not explicitly explained. The model is used to explain both growth and also the increase in performance of innovations. The curve follows a process of initial experimentation followed by stabilisation (Abraham & Knight, 2001, p. 23). Once the innovation has outlived its product lifecycle, it dies. Future S curves of new innovation pick up from where the old technology has left off. This is illustrated below in Figure 20.

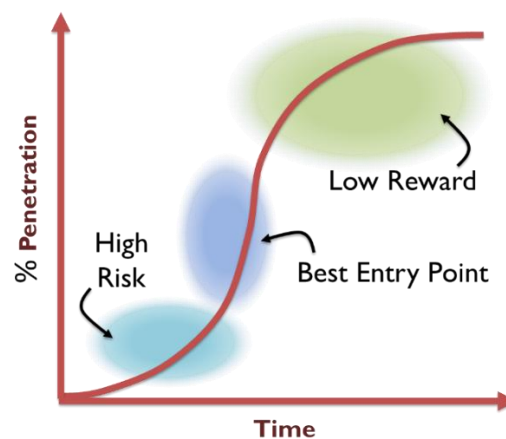


**Figure 20 - The S Curve model, redrawn from Abraham & Knight (2001, p. 24)**

It is important to understand this curve in relation to the different strategic aims of businesses promoting innovations at each stage of the cycle. Early ventures seek to gain competitive advantage over incumbent technologies through newness, whilst mature innovations seek to explore or “milk” the benefits of past investment in innovation (Abraham & Knight, 2001, p. 23). At the end of an old innovations lifecycle, businesses are faced with two choices: extracting ever diminishing rewards from outmoded technologies which eventually result in a downward spiral of decline or innovating and joining the new wave of innovation.. Perhaps this is the point at which the vehicle industry finds or will soon find itself? Some regime manufacturers are starting to invest heavily in new technologies.

The question for those who are heavily invested in the regime is what is the right point at which to invest in innovating? Investment in the next stage of innovative development is risky. Funds must be invested into the development of new products with no immediate return. Even when new products are introduced, the profitability of ventures may still be low until sales reach the point at which they can pay off the development costs of the new product. This in part accounts for companies' reluctance to innovate. However, it is this risk which must be offset against the risk of others who are willing to face the challenges of NPD in order to gain market share.

Investing early in innovative technology risks pouring money into primary technology development that others later benefit from. However, investing too late can result in other regime actors having already made the transition, whilst niches erode market share. The best entry point therefore is at the inflection point where the pace of innovation starts to accelerate. This is shown in Figure 21 below. This graph can be considered in combination with later discussions of risk and uncertainty presented in Figure 35 on p.114.

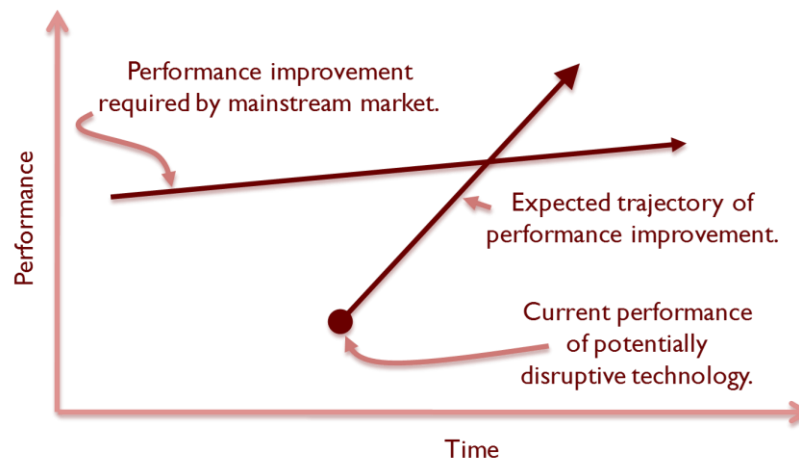


**Figure 21 - Risk & Reward at different points of the S Curve**

From the corporate perspective, it is imperative that the timing of the introduction of new innovations is appropriately pitched. If it is too early, a technology could be introduced with potentially insufficient performance that the market is not ready for; if it is too late, the rewards of innovation are diminished as competitors have already entered the space. Having examined the nature of innovation, the next section examines the speed and pace of innovation.

### 2.4.5 The Pace of Innovation

In the opening section on innovation (p.73), it was established that this study is interested in innovation from two perspectives: innovation that has the potential to contribute to sustainable development and also to firm performance. From the firm's perspective, innovation is only worthwhile if it improves a competitive advantage by its introduction. The debate endures about the rate of innovation required to address challenges of sustainability. The spectrum of views in this debate mirrors the many archetypes of sustainability (p.4). The previous section assessed at what point incumbent regimes invest in innovation, but sometimes the pace of innovation is so fast, and niches develop with such speed that the technology 'disrupts' the marketplace faster than the regime is able to respond.



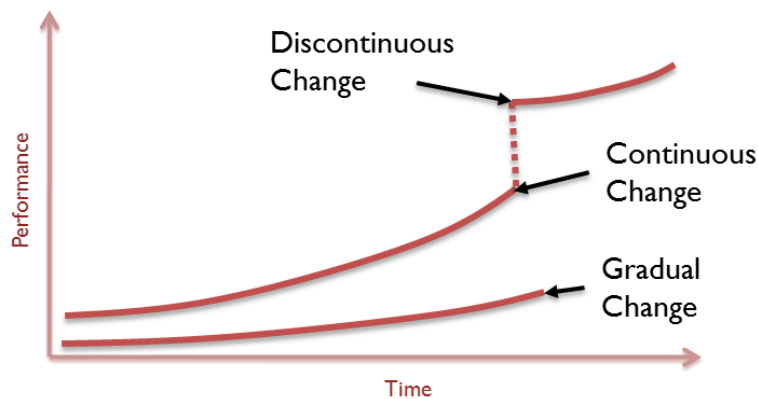
Bower & Christenson (2010)

**Figure 22 - Conventional technologies vs. disruptive technologies**  
(Bower & Christenson, 1995, p. 9)

With disruptive technologies, the newer technologies often have performance attributes that are different from the companies' existing customer bases value (Bower & Christenson, 1995, p. 3). Also, the performance attributes that customers do value can improve at such a rate that the disruptive technology can invade the markets of the established technology (Bower & Christenson, 1995, p. 3). One theme that is specific to the automotive industry is that historically its prohibitively high barriers to entry have been a significant challenge to new entrants wishing to compete in this arena; as such a disruptive challenger technology has not emerged to challenge the dominant regime's formula.

## 2.4.6 Continuous vs. Discontinuous Change

In Christenson's (1995) lexicon, this study has seen conventional technologies vs. disruptive technologies, whose trajectory of performance improvement is faster than the gradual performance improvements of incumbents' technologies. Whilst the speed of performance improvement is one consideration, another is whether change can be discontinuous, that is making a sudden jump in performance from one level to a radically higher level and challenging the status quo of a sector in the process.



**Figure 23 - Gradual, Continuous & Discontinuous Change redrawn from Abraham & Knight (2001, p. 23)**

Abraham & Knight (2001, p.23) cite Intel's Andy Grove as defining these radical shifts as "strategic inflection points", and note that 'a tenfold improvement in performance occurs'. At these points there is the potential for "breakthrough change" and a radical disruption of industries. Abraham & Knight define this type of growth as an "overwhelming increase in growth and profitability that leapfrogs the competition". Is the industry at that point with Ultra Low Emission Vehicles? It is worth returning to Andy Grove, about whom the technology press have said has a "knack for sensing when circumstances should force changes at a company or an industry". In 2008 (Associated Press) the man who coined the term believed electric vehicles had reached a "strategic inflection point". The next section evaluates who – incumbents or insurgents – may be best placed to capitalise on this period of change.

***"The drumbeat of the electrical transportation is accelerating like nothing I've ever seen in my life."***

**Andrew Grove, Former Head of Intel**



### 2.4.7 Innovation: Insurgents vs. Incumbents

The fifth research sub-theme focuses on the role of incumbent and insurgent firms (see p.40), and, in particular, their respective approaches to innovation. The embedded case studies in this thesis are delineated into two groups; on the one hand, the 'volume' vehicle industry and, on the other, smaller 'niche' entrants to the marketplace. There are explicitly issues of scale involved in comparing two groups of companies with very dissimilar operations. The nature of managing innovation in SMEs (Dodgson, Gann, & Salter, 2008, pp. 126-130) differs radically from that used in big firms. Later, in the conclusions, the role of incumbents and insurgent firms in the case studies are discussed (see p.408).

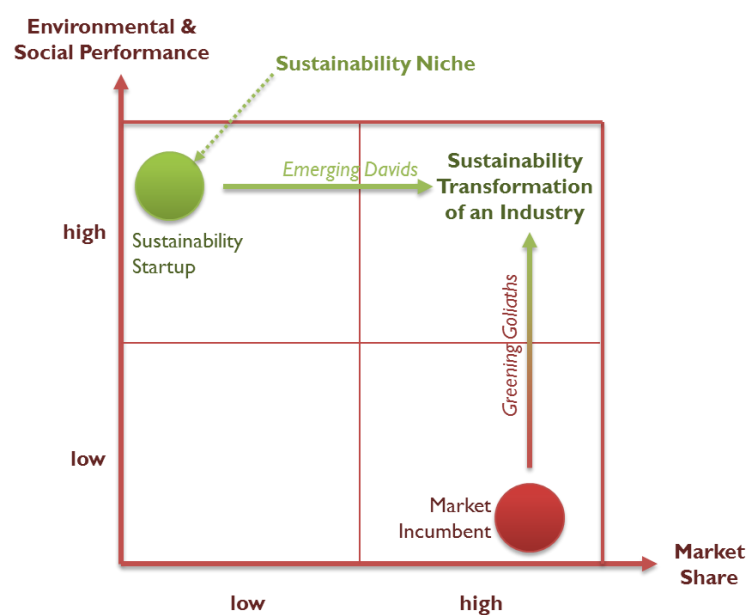
This structure reflects an enduring question that is hotly debated by scholars of management; does innovation come from established incumbent players in any given sector or new entrants to that sector? There is an observed phenomenon, supported by empirical studies (Abernathy & Utterback, 1978; Christensen, 1997; Tushman & Anderson, 1986; Utterback, 1994) that shows incumbent firms often suffer from poor performance in markets characterised as undergoing a period of rapid technological development.

Not all completely accept this model; Hill & Rothaermel (2003, p. 257), who characterise this phenomena as the 'standard' model of innovation, do not believe that this is a universal tendency amongst all incumbents. In their study of 'outlier incumbent firms' that prosper, they identify a number of factors which have helped incumbent firms to survive technological discontinuity. These factors include investment in basic research and '*legitimization and institutionalization of autonomous action*'. They also suggest [citing (Rothermael, 2001)] that there are '*entire industries [...] where the incumbents seem to survive and prosper despite the appearance of radical technology.*'

Falck (2008, p. 4) explores the barriers that hinder incumbents from innovating, citing Knight (1921) who in early thinking on the field advances the notion that the gains from bringing new innovations to market are too uncertain for incumbents, whereas profit from existing product lines are more certain. This provides little motivation for change. In more contemporary literature, Falck (2008, p.4) cites Acs, Morck & Yeung (1999) who expand upon the effect of incumbents' complacency, in particular

stating that it is exacerbated in ‘large incumbent firms with performance-oriented remuneration systems’ where employees are rewarded for preserving the sales volumes of old innovations. Indeed, Maxton & Wormald (2004) make this same critique of the automotive industry’s obsession with ‘shifting metal’ (moving large volumes of vehicles), rather than concentrating on profit and product. Hill & Rothaermel (2003, p. 257) provide some additional evidence from the ‘standard’ model of innovation, drawing differences between funding regimes and economic incentives for new entrants and incumbents and the incumbents being ‘embedded’ in an industry networks that sees little value in new innovations. All contribute to the problem. There is an optimum level of competition in order to stimulate innovation (Aghion, 2006, p. 4); if there is no competition then there is little incentive to innovate but, if competition is too fierce, potential innovators are dissuaded as they are less likely to benefit or gain from innovating.

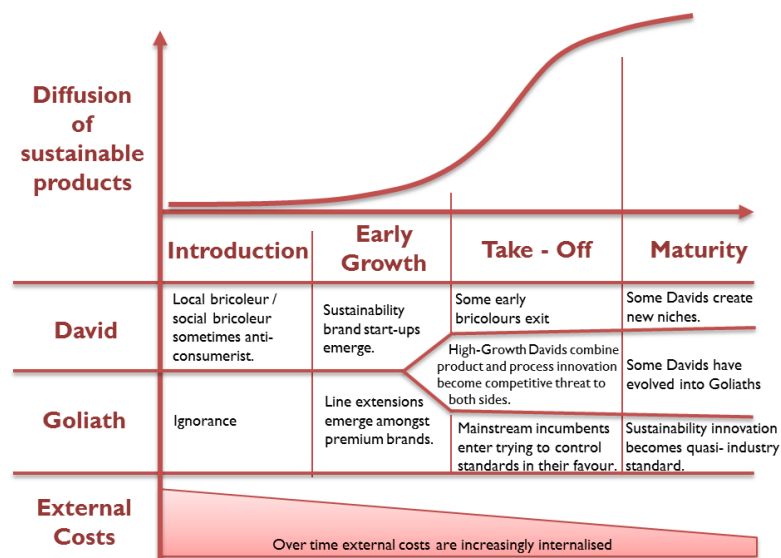
How does this argument translate into understanding the role of incumbents vs. insurgents in sustainable innovation? Hockerts & Wüstenhagen (2010) characterise new green start-ups as ‘Emerging Davids’, whilst incumbents that are adapting to the challenges of sustainability are characterised as ‘Greening Goliaths’. This is illustrated in Figure 24 below.



**Figure 24 - Co-evolution of sustainability start-ups and market incumbents towards the sustainability transformation of an industry (Hockerts & Wüstenhagen, 2010, p. 488)**

New entrants are essential to creating a competitive environment, which prevents incumbent firms from becoming complacent. Aghion (2006, p. 2) builds the case for new-entrant firms in trying to explain why the EU15's average yearly growth of GDP per capita has lagged behind the US in the preceding 10 years by 0.4 percentage points. Sorted by market capitalisation, 12% of the 500 largest US firms were founded in the preceding twenty years vs. 4% in Europe (Aghion, 2006, p. 3).

How can these two scales of firm be reconciled and, as the products make their way into the mainstream, how might these two types of company co-evolve? Hockerts & Wüstenhagen (2010) go on to explain how these two distinct types of firm may co-exist and potentially grow together as sustainable products diffuse into the marketplace.



**Figure 25 - The Evolution of 'Greening Goliaths' and 'Emerging Davids'. (Hockerts & Wüstenhagen, 2010, p. 483)**

Other authors have also written on this subject. Falck (2008) observes that one of the most obvious ways for knowledge to be transformed into innovation is for employees to leave incumbents and start their own venture. One of the most high-profile examples of this is General Motors' executive John Z. Delorean who left to set up the Delorean Motor Company. Whilst ultimately his venture proved a failure, it is illustrative of how knowledge from an industry can result in the creation of new challenger companies. Will new innovative business models prompt more defections from the mainstream?

#### 2.4.8 Innovation and the Business Model

Tongur & Engwall (2014) note that *'technology shifts are lethal to some manufacturing businesses'*. Innovative transitions can prove a significant business model challenge for those mature firms who are faced with a wave of innovation against which to defend their business. Tongur & Engwall (2014) note that the extant literature proposes two approaches: investment in R&D or changing the firm's value proposition – both of which are technology based approaches which contain *'inherent uncertainties'*. (Tongur & Engwall, 2014). Tongur & Engwall (2014) note that technological innovation presents a *'business model dilemma'* for the mature firm.

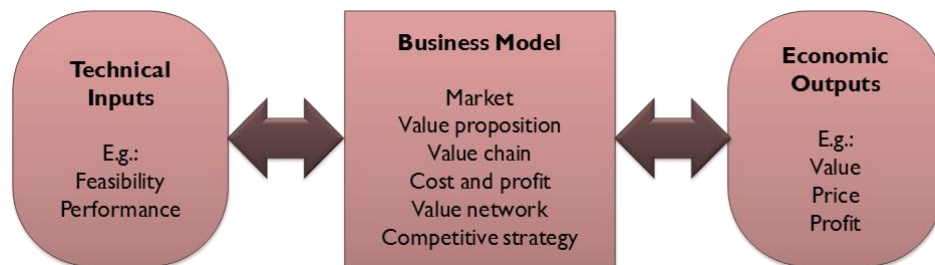
To counter this view from large established firms, innovation is surely a challenge for small firms? If large firms with large budgets cannot develop new technologies and bring them to market, how can new firms hope to afford to introduce innovation? Rhoads, Townsend & Buznitz (2013) who note *"Resource-based logic contends that firm performance is a product of superior resource endowments"* counter this with the observation that *"many firms initiate operations with significant resource constraints and still generate superior performance."* Through empirical analysis of a range of small firms, they conclude that *"firm's business model attenuates the challenges associated with commercializing radically, new technologies thereby improving firm performance."*

These two innovation perspectives from the large firm and the small represent two sides of the same coin: How does 'the business model' relate to innovation?

The relationship between "innovation" and "competitive advantage" is not straightforward being *"connected by complex and multi-dimensional relationships"* (Lengnick-Hall, 1992, p. 399). Furthermore motivations for innovation vary between those driven by consumers, regulation and competitors.

Chesborough & Rosenbloom's (2002) model (displayed overleaf) is key, as it makes the link between the technical potential of innovation and the economic potential of the business, with the business model providing the logic to mediate between the two domains. Timmers (1998, p. 2) highlights that having a good business model is insufficient if it is reliant upon technology that does not meet the

performance criteria dictated by the model stating that *“The a priori feasibility of technical implementation of the architecture of any business model depends very much upon the state-of-the-art of the technology”*.



**Figure 26 - The Business Model Mediates Between The Economic and Technical Domains**

**Chesbrough & Rosenbloom's (2002, p. 536)**

One issue that is raised in the next chapter (p.157) is the notion of some radically innovative technology concepts. Some of these have well-articulated business models that show how value can be realised; however, others are innovative technologies ‘wanting for a business model’ to make them work for consumers. Teece (2010, p. 173) also subscribes to this view, saying *“To profit from innovation, business pioneers need to excel not only at product innovation but also at business model design”*.

New technologies may require “innovative business models”, but equally they may not; the question of “business model innovation” as contrasted with “technical innovation” is one that is explored later on p.105. The important point is that technological innovation can sometimes occur within business models that remain the same. Some technological innovation however, will require business model innovation. Equally, it is possible to create innovative business models using existing technologies.

Timmers (1998, p. 2) highlights *“technology in itself provides no guidelines for selecting a model in commercial terms”* but goes on to clarify that *“guidance to technology development can come from the definition of new [business] models”*. Baden-Fuller & Haefliger (2013) also pick up on this theme, noting that business models are separable from technology. They rephrase Chesbrough & Rosenbloom (2002) instead saying that the business model mediates between technology and firm performance. However, Baden-Fuller & Haefliger (2013) note that the second question is to consider is selecting the right technology, which is a matter of business model choice.

## 2.5 'Business Model' Literature

In the next couple of sections, the extant literature on 'business models' and the challenges of widespread confusion as to how to define the business model will be reviewed. This is no mean feat, as the literature has developed rapidly, with an explosion of articles in recent years examining aspects of the concept. Despite this massive concentration of academic endeavour, no common definition of business model has yet emerged.

Magretta (2002) quotes Michael Lewis as saying that the word 'Business Model' rose to particular prominence during the dot-com boom, where it was routinely invoked to "*glorify all manner of half-baked plans*". Some claim that the Business Model concept is just a recasting of old ideas in new clothes, whilst others argue that the concept of business models is a new development in management scholarship. Wells (2013, p. 23) notes the duality that "*with any new idea or concept, there are those who will seize upon it as the answer to everything, and a whole new way of thinking about the world, and there are those who will dismiss it as simply another manifestation of an idea that has long existed.*". Whether it is just a 'packaging' of old ideas, or represents something novel, one thing that is not in question is its contemporary popularity.

Baden-Fuller & Haefliger (2013, p. 419) provide one metric of success of the 'business model' concept, noting that "*in the three years since publication, the Long Range Planning (2010) special issue on business models attracted more than 150,000 downloads and more than 3,500 Google Scholar and more than 500 ISI citations.*". Wells (2013, p. 23) also notes that, despite the shortcomings associated with the lack of definition, "*the concept of business models is well suited to the task of considering how businesses fit into the future of sustainability*".

This literature review has attempted to keep up to date with developing ideas in the field. Given the degree to which it has grown, this has presented practical and intellectual challenges. Despite developments and changes, at the core of this research, the "Business Model Ontology" of Osterwalder & Pigneur (2002) has remained static as a concept and enjoyed widespread approval by practitioners and academics alike; and therefore seems a solid choice on which to base this analysis.

### 2.5.1 Defining Business Models

Timmers (1998, p. 2), writing very early in the evolution of the business models literature, highlighted that the term ‘business model’ is used inconsistently and often without any explicit statement by various authors as to what they mean by the term.

***“...the executives, reporters, and analysts who use the term "business model" don't have a clear idea of what it means. They sprinkle it into their rhetoric to describe everything from how a company earns revenue to how it structures its organization”***

---

(Linder & Cantrell, 2001, p. 2)

Unfortunately, as the literature has evolved there appears to be little resolution to this vexing problem in sight, even a decade on, Zott, Amit, & Massa (2011) were finding the same challenge.

***“Business models are perhaps the most discussed and least understood aspect of the web. There is so much talk about how the web changes traditional business models. But there is little clear-cut evidence of exactly what this means.”***

---

(Zott, Amit, & Massa, 2011)

Despite this, the term has an enduring popularity. Magretta (2002) defines business models as “*stories that explain how enterprises work*”, and to some ends this lends credence to a qualitative approach to investigating business model design. However, much as in literary circles, there is discussion of the construction of story and narrative, so there must be common themes in telling the stories of firms.

Osterwalder & Pigneur (2002) advance the definition that a business model is “*a conceptual tool that contains a set of elements and their relationships and allows to express the business logic of a specific firm.*”

They cite (Slywotzky, 1995) who offers a more expanded definition “*the totality of how a company selects its customers, defines and differentiates its offerings, defines the tasks it will perform itself and those it will outsource, configures its resources, goes to market, creates utility for customers, and captures profit. It is the entire system for delivering utility to customers and earning a profit from that activity.*”

Overleaf, a table of different business model definitions that appear in the literature is presented.

<b>Author</b>	<b>Definition</b>
<b>Slywotzky (1995)</b>	<i>“the totality of how a company selects its customers, defines and differentiates its offerings, defines the tasks it will perform itself and those it will outsource, configures its resources, goes to market, creates utility for customers, and captures profit. It is the entire system for delivering utility to customers and earning a profit from that activity.”</i>
<b>Timmers (1998)</b>	<ol style="list-style-type: none"> <li>1. <i>An architecture for the product, service and information flows, including a description of the various <b>business</b> actors and their roles.</i></li> <li>2. <i>A description of the potential benefits for the various <b>business</b> actors.</i></li> <li>3. <i>A description of the sources of revenues.</i></li> </ol>
<b>Linder &amp; Cantrell (2001, p. 1)</b>	<i>When people speak about "business models," they could be speaking about three distinct things: components of business models, real operating business models, and what we call change models. A business model, strictly speaking, is the organization's core logic for creating value. A change model is the core logic for how a firm will change over time in order to remain profitable.</i>
<b>Afuah &amp; Tucci (2001)</b>	<i>“A good business model begins with an insight into human motivations and ends in a rich stream of profits.”</i>
<b>Osterwalder &amp; Pigneur (2002)</b>	<i>“a conceptual tool that contains a set of elements and their relationships and allows to express the business logic of a specific firm.”</i>
<b>Magretta (2002)</b>	<i>“stories that explain how enterprises work”,</i>
<b>Hedman &amp; Kalling (2003, p. 49)</b>	<i>“business model is a term often used to describe the key components of a given business”</i>
<b>Tikkanen, Lamberg, Parvinen, &amp; Kallunki (2005, p. 789)</b>	<i>“The business model is a cognitive system through which managers decide on their actions.”</i>
<b>Teece (2010, p. 172)</b>	<i>The business model is “... architecture that the company has chosen for its value creation and appropriation mechanisms.”</i>

**Table 8- Selected Business Model Definitions**

There are a range of characterisations of what a business model is; unsurprisingly that also translates into a variety of interpretations as to what components constitute a business model – and how if the business model is broken down, what ideas are at its nucleus.

This point has been reinforced by Shafer Smith & Linder (2005) who highlight that, whilst the word business models has entered the management vocabulary, there is confusion, lack of definition and over generalisation in how the term is used and a lack of consensus and definition in the academic community as to what constitutes a business model. In the period 1998-2002 they found twelve differing definitions of what constitutes a business model; none of which had been commonly accepted or adopted by the business and academic community.



Early in the development of the business models literature, Pateli & Giaglis (2003) set about examining the research on business models to date and providing a classification of how those different strands of literature had contributed to the understanding of the “business models” concept. Their work is set out in the table below.

	Definitions	Components	Taxonomies	Representations	Change methodologies	Evaluation models
Timmers (1998)	●		●			
Mahadevan (2000)		●	●		●	
Kraemer et.al. (2000)		●				
Tapscott et.al. (1998, 2000)	●		●	●	●	
Hamel (2000)		●				●
Linder & Cantrell (2000)	●	●	●		●	
Kaplan & Sawhney (2000)			●			
Chesbrough & Rosenbloom (2001)		●				
Methlie (2001)		●				
Afuah & Tucci (2001)		●				●
Alt & Zimmerman (2001)		●	●			
Gordijn & Akkermans (2001)	●			●	●	●
Weill & Vitale (2001)	●	●	●	●		●
Rappa (2001)	●		●			
Hawkins (2001)	●					
Amit & Zott (2001)	●					
Applegate (2001)	●		●			
Petrovic et.al. (2001)	●	●				
Auer & Follack (2002)	●	●			●	
Papakiriakopoulos et.al. (2001)					●	
Osterwalder & Pigneur (2002)	●	●		●		
Magretta (2002)	●	●				
Eliot (2002)	●					

Table 9 - Pateli & Giaglis (2003)

Some conceptions of ‘business model’ provided ‘definition’ to the concept and indeed this was one of the strongest themes in the literature examined at the time. Others broke the concept of a business model down into smaller ‘components’. This ranked secondarily by the number of business model papers that considered business model components.

This thesis seeks to make comparisons between the different business models that are being employed at a variety of levels within the UK car industry, and therefore a tool or common metric was required to make representations and comparisons between business models. In Pateli & Giaglis' evaluation of the literature, they considered how many business model papers provided 'Representations' of a business model; they then expanded upon this definition as "*representational formalisms for visualizing the primary components of a BM and their interrelationships.*" (Pateli & Giaglis, 2003, p.332).

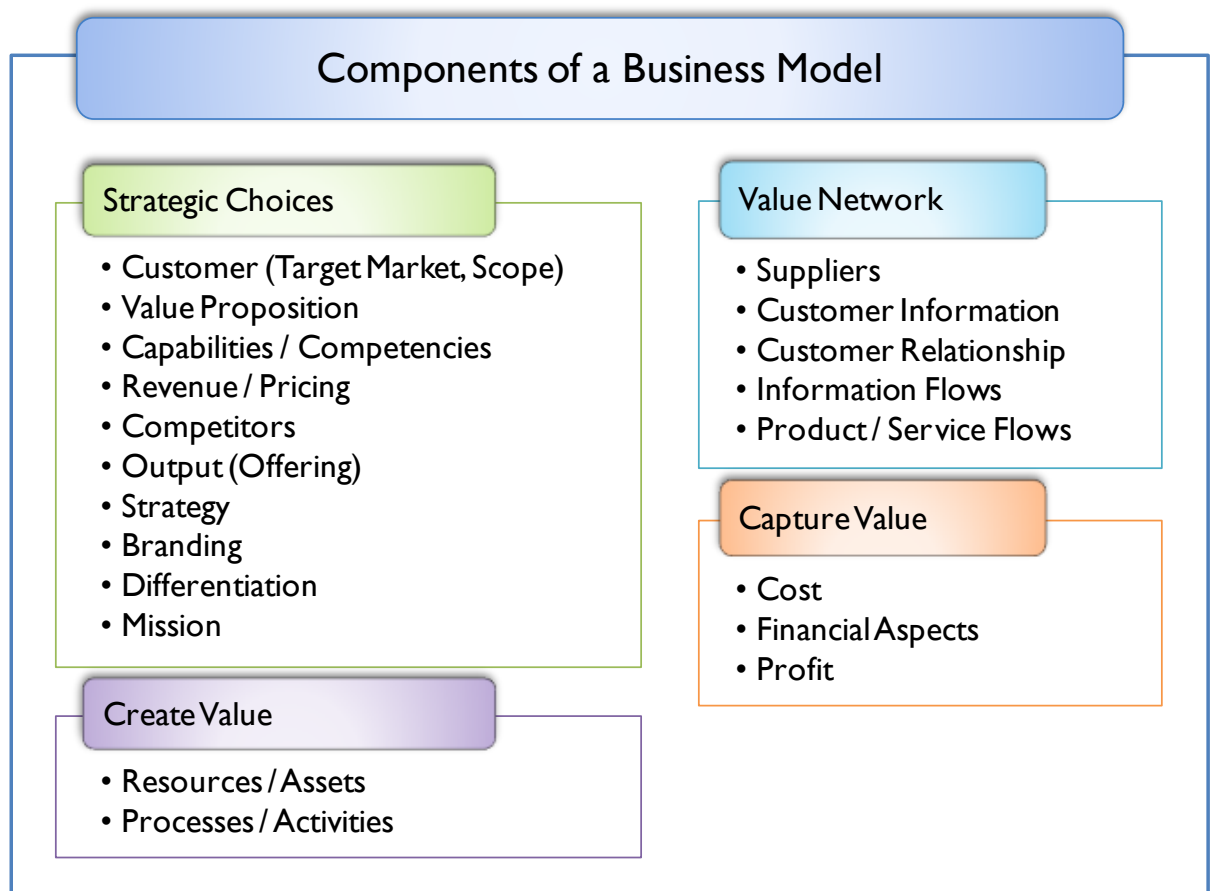
The Business model concept which was advanced by Osterwalder & Pigneur (2002) provides definition to the business model through breaking it down into a series of components. It is notable for having gained traction in both communities of academia and practice and it provides the 'representation' of different firms that is essential for comparisons to be made. This justifies the selection of this model above others for this thesis.

However, there are three additional categories that Pateli & Giaglis (2003) considered: Taxonomies, Change methodologies & Evaluation Models. Whilst Osterwalder & Pigneur (2002) do not provide a 'taxonomy' of different types of business model, their business model canvas provides classification and dissection of business models in such a way that allows for discussion of different taxonomies of business model based around the configuration of their business model components. Completed business model canvases have been used in order to "map out" different types of business logic, in such a way that labels can be applied to them.

Later in this section, the differentiation between "Change Models" and "Business Models" is expanded upon in more detail. Osterwalder & Pigneur's (2002) model is only capable of capturing "snapshots" of business logic at any one time. It does not provide the facility to document how this logic will change over time – however; whilst we can speculate about how firm's business models might evolve, this study is effectively a "snapshot" of a range of firm's business models at this point in the transition. Furthermore, as will be made clear in the methodology, it is not an "evaluation" of the commercial viability of the businesses examined, so an business model framework that allows for 'evaluation' is not necessary.

Shafer, Smith & Linder (2005) advance the view that aspects of business models can be classified into four categories: strategic choices (See Figure Figure 27), the value network, creating value, and capturing value. From the sources reviewed, they classified those components cited two times or more into the following affinity diagram (being an approach they reference from Pyzdek (2003)).

There is a great deal of commonality with this approach, and that of Osterwalder & Pigneur (2002) whose business model canvas considers on the one side how value is “created” and on the other hand how value is “captured”; however, there are also some significant variations.



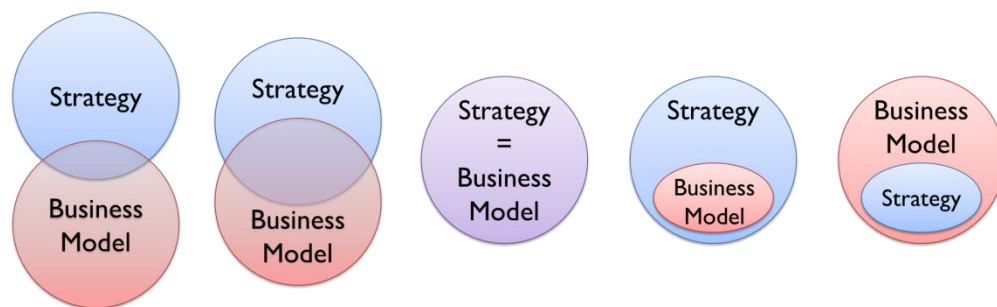
**Figure 27 - Affinity Diagram of Business Model Components – Redrawn from: (Shafer, Smith, & Linder, 2005)**

This cuts to another significant challenge in business model definition, where scholars are unable to agree – to what degree do the concepts of ‘strategy’ and ‘business models’ overlap? Are strategic choices embedded within the business model, or are they something separate? These challenges of definition are discussed in the next section.

## 2.5.2 Differentiation from Strategy

Foss & Stieglitz (2014, p.5) perspective on the relationship between business models and strategy is that “the business model concept has drawn attention to a fundamental perspective in strategy that arguably was present at the inception of strategy thinking but was forgotten as academic specialization came to characterize strategic management.”, what is it that has been lost and what differs between them?

There is significant interface between the concepts of ‘business models’ and ‘business strategy’, and the liminal space between the two concepts is contested within the literature. Margretta (2002) asserts that “a business model isn’t the same thing as a strategy, even though many people use the two words interchangeably”. Seddon & Lewis (2003, p. 3) visually articulate different conceptualisations of the relationship between the concepts of ‘Strategy’ and ‘Business Model’ – shown in Figure 28 - which are expressed by different authors within the literature.

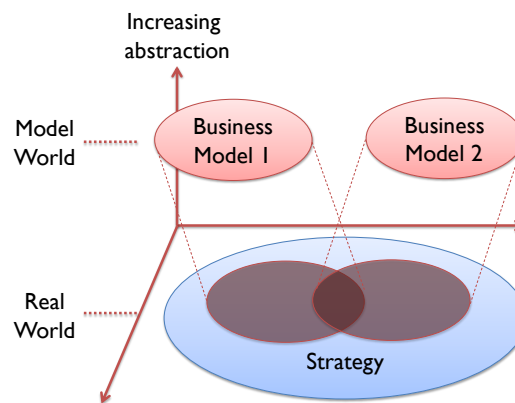


**Figure 28 - Possible Overlap Between the Concepts ‘Strategy’ and ‘Business Model’**  
Redrawn from: Seddon & Lewis (2003, p. 3), [colour author’s own]

‘Strategy’ has been the dominant discursive term within the business literature for many years. Indeed, in Seddon & Lewis (2003, pp. 3,4) a Google search for the term ‘business model’ returned around 1 million searches, whilst a search for the term ‘strategy’ revealed 17 million searches. Indeed, repeating their experiment in 2013 is revelatory with ‘business model’ returns 17 million results and ‘strategy’ returns 402 million results. Strategy is still the dominant discourse. Yet, the two concepts aim to explain business performance and, whilst there are ‘nuances of difference’, Seddon & Lewis (2003, p. 3) advance that the concepts are ‘substantially the same’. Seddon & Lewis also (2003, p. 5) provide an account of the evolution of the Harvard School’s conceptualisation of strategy noting that it is only more recently that ‘business model’ has entered the management lexicon and been developed substantively as a concept. Other authors see these as having quite distinct attributes. Wells (2013, p. 28) cautions against ‘conflat[ing]’ the two concepts and illustrates with an example of Wal Mart,

delineating between a 'business model' of 'pile it high and sell it cheap', but a 'strategy' of identifying towns large enough to support a store but with insufficient population to support more than one.

This is a good illustration, however arguably, referring back to Table 10, p.98, there are some business model *ontologies* which could capture elements of this strategy. If Osterwalder & Pigneur's (2002) business model ontology is applied, it could capture some of the strategic logic under the heading of 'Customer Channels'. Seddon & Lewis (2003, p. 3) differentiate between the business model existing in the "model world", but the business of strategy existing as a real world construct. Models that are constructed as distinct in an abstract modelling space, may overlap when applied in the real world.



**Figure 29 - The relationship between Business Models & Strategy**

**Redrawn from Seddon & Lewis (2003, p. 3)**

Considering how this perspective relates to the automotive industry, Walters & Newton (2010, p. 1) raise concern that, in many VMs, "the business model has often taken second place to strategy in management thinking and focus". If this is viewed through the lens of Seddon & Lewis (2003) and their conceptualisation of the relationship between business models and strategy, then the quote can be reframed: in many VMs, the core operating logic of the business has taken second place to inter-firm competition and positioning relative to other firms.

I take the view, that both are distinct 'modelling tools' used to create abstractions of reality. As concepts, there is some degree of overlap and co-shaping. The strategic intent can shape the configuration of the business model, whilst the configuration of the business model in turn shapes the strategic options available to the firm.

### 2.5.3 Business Model Components

When ‘business models’ are discussed in the literature, whilst there is divergence as to the definition of what constitutes a ‘business model’, there is also widespread disagreement as to what ‘sub units’ of analysis comprise the business model. Shafer, Smith & Linder (2005) provide a summary. Whilst this thesis adopts a specific business model ontology, Shafer, Smith & Linder’s (2005) table below, shows the breadth of divergence in the literature as to potential business model components.

	Timmers (1998)	Hamel (2000)	Ahish and Tucci (2001)	Amis and Zott (2001)	Veill and Vitale (2001)	Dubossier-Torbay et al. (2002)	Magretta (2002)	Rayport and Jaworski (2002)	Van der Vorst et al. (2002)	Hoque (2002)	Cheabrough (2003)	Hedman and Kalling (2003)
Value network (suppliers)	●	●			●	●			●	●	●	●
Customer (target market, scope)		●	●			●	●	●		●	●	●
Resources / assets		●		●		●		●		●		●
Value proposition			●			●	●	●	●		●	
Capabilities / competencies		●	●	●		●						●
Processes / activities		●	●			●			●			●
Revenue / pricing	●	●	●			●					●	
Competitors								●		●		●
Cost						●	●				●	
Information flows	●			●	●							
Output (offering)				●								●
Product / service flows	●			●	●							
Strategy		●								●	●	
Branding						●				●		
Customer information		●				●						
Customer relationship		●				●						
Differentiation		●								●		
Financial aspects						●		●				
Mission		●								●		
Profit						●	●					
Business opportunities				●								
Cash flows					●							
Create value				●								
Culture										●		
Customer benefits								●				
Customer interface		●										
Economic logic							●					
Environment										●		
Firm identity										●		
Firm reputation										●		
Fulfilment and support		●										
Functionalities									●			
Implementation			●									
Infrastructure - applications									●			
Infrastructure - management						●						
Management												●
Product innovation						●						
Specific characteristics									●			
Sustainability			●									
Transaction content				●								
Transaction governance				●								
Transaction structure				●								

**Table 10 - Comparison table of business model elements identified in the literature [up to 2003] (Shafer, Smith, & Linder, 2005)**

Since their analysis, the literature has evolved, however, no clear definition has emerged and any number of contemporary sources all make reference to the fact, that there is still a divergence of opinion regarding how to define business models (Foss & Stieglitz, 2014; Günzel & Krause, 2013; Meertens, Starreveld, Iacob, & Nieuwenhuis, 2013).

For those wanting to work with business models in practical research, the rational approach therefore is to state the conceptualisation of the 'business model' that is being used to give form to the concept.

Another corollary debate, is whether a business model must be considered as a whole, or if subdivided, how much information about the business model is lost? Casadesus-Masanell & Ricart (2010) have argued that business models can be analysed as a whole or decomposed into their constituent parts. Furthermore, they argue that within a single firm, can be a "bundle" of different business models.

***Some business models are decomposable, in the sense that different groupings of choices and consequences do not interact with each other, and thus can be analysed in isolation. Depending on the question to be addressed representing just a few parts of the organisation's business model may be appropriate.***

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**Casadesus-Masanell & Ricart (2010, p.5)**

Foss & Stieglitz (2014, p.24) put this in a different way, saying that some business model innovations are "modular" whilst others are "architectural". Business Model Innovations can involve tweaking small components of the business model, or radical reconfiguration of the whole web of interacting components. The third research sub theme focuses (p40) specifically on the concept of "business model components", how they should be defined, and whether they can be considered in isolation, or as part of a gestalt. This is a theme that will be returned to in the conclusions on page 388. Here, there are two types of analysis that are used; the conclusions make reference to both individual components of business models, and the business models as a whole.

The tool that is used in this research to examine the business models, is Osterwalder & Pigneur's (2002) Business Model Ontology.

#### 2.5.4 Business Model Ontology

One of the most developed Business Model Ontologies has been advanced by Osterwalder & Pigneur (2002). It is their ontology that will be taken forward in this thesis. Searle & White (2013, p.46) note that the Osterwalder & Pigneur (2002) definition of Business Models is ‘*more succinct*’ than Chesbrough & Rosenbloom (2002) and provides a “*working definition of business models that is in line with the use of business models as a research topic*”. Osterwalder & Pigneur (2002) define the business models as a template of nine interconnected business model components:

##### **KEY ACTIVITIES**

What activities are important to create value for the customer? What does the firm ‘do’?

##### **KEY RESOURCES**

What resources does the firm use to create value for customers? What are the company’s assets?

##### **KEY PARTNERS**

Who does the firm work with to deliver value? What sort of relationships does it engage in?

##### **VALUE PROPOSITION**

What is the firm’s product / service value proposition to the customer? What does it do differently?

##### **CUSTOMER RELATIONSHIP**

What sort of a relationship does a firm have with its customers?

##### **CUSTOMER CHANNELS**

What are the mechanisms the firm uses to distribute value? These could be physical or virtual.

##### **CUSTOMER SEGMENTS**

What types of customer does the firm target? Are they a niche / mass market?

##### **COST STRUCTURE**

What are the firm’s costs in delivering upon its value proposition for the customer?

##### **REVENUE STREAMS**

How does the firm generate revenue from the customer? How does it get paid for its value?

In turn, the business model ontology configures these components into a “business model canvas”. This is represented overleaf in Figure 30. These activities are grouped into four sections. Namely ‘Infrastructure’ (highlighted yellow) – what resources and assets does a firm need and use. The ‘Offering’ colour coded green; what is it the firm offers. ‘Customers’ how does a firm relate to its customers, and ‘Finances’; the flow of money into and out of a business.



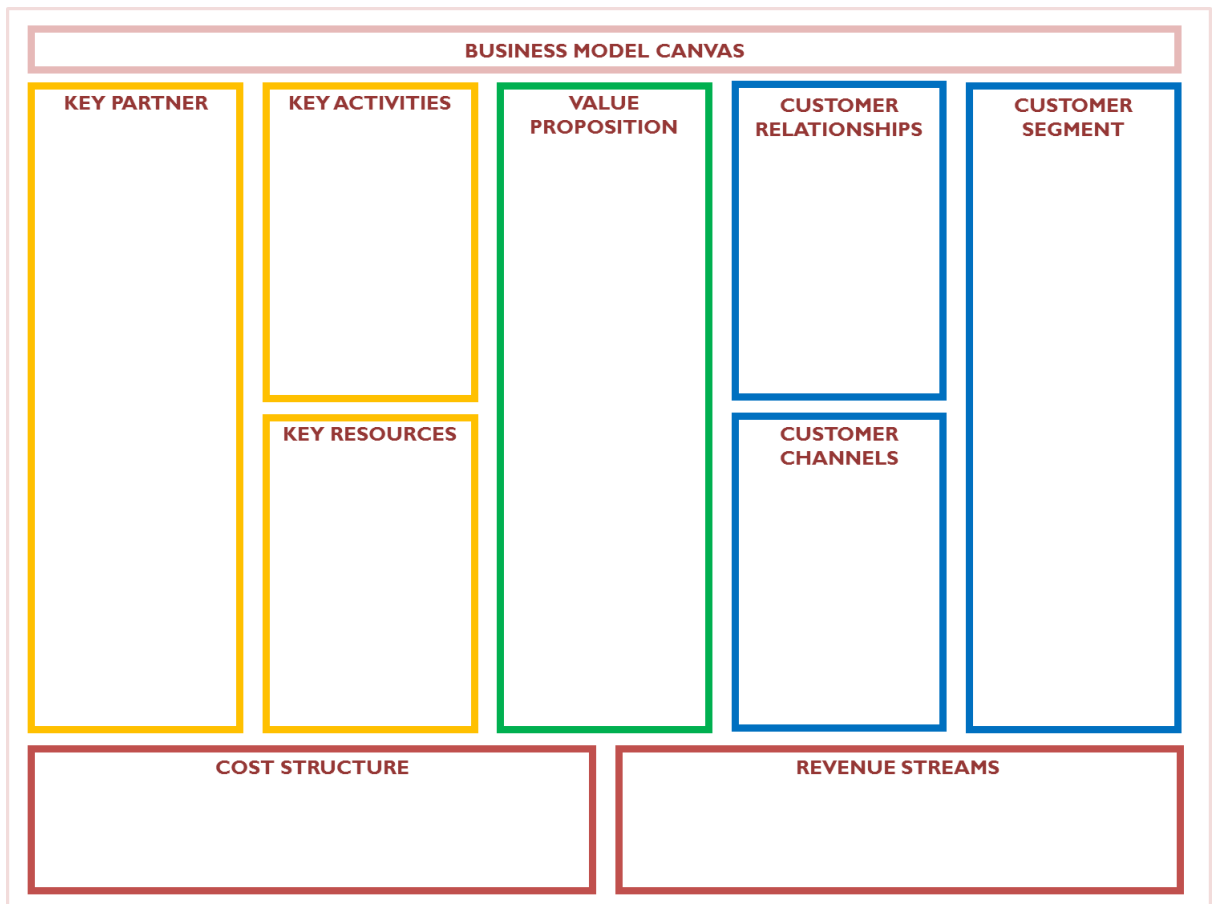


Figure 30 - A Generic Business Model Canvas

### 2.5.5 Commercial Support for the Business Model Ontology

The Business Model Ontology has been adopted by a wide range of corporate clients, in order to help them better understand their businesses and processes. Given the “engaged scholarship” perspective of this work, this is seen as a particularly useful indicator and validation of the methodologies usefulness. Business Model Generation (2014) list on their website, under “Proud Practitioners of the Methodology”, a diverse roster of well-known corporate users of the methodology: *3M, Adobe, Alcatel Lucent, Cap Gemini, Deloitte, Desjardins, Ericsson, Ernst & Young, Fujitsu, General Electric, Habitat for Humanity, Hermes, Humana, Intel, Intuit, Mastercard, Michelin, NASA, Oracle, Price Waterhouse Coopers, SAP, University of California, WWF & Xerox*. This list is extensive but not exhaustive, and indeed represents only a small fraction of companies that have used the process. However, the calibre of successful enterprises using the approach lends some credence to assertions of proven effectiveness. Part of the business model canvas’ appeal, is its ability to be used as a planning tool.

## 2.5.6 The Business Model as a Planning Tool

The Business model is a useful planning tool for enterprises. As Magretta intones (2002) “A business model’s great strength as a planning tool is that it focuses attention on how the elements of the system fit into a working whole”, whereas perhaps strategy defines both the relative positioning of the business model in relation to its competitors and also the manner of implementation of said business model? Timmers (1998) frames the point that:

**“A business model in itself does not yet provide understanding of how it will contribute to realise the business mission of any of the companies who is an actor within the model. We need to know the marketing strategy of the company in order to assess the commercial viability and to answer questions like: how is competitive advantage being built, what is the positioning, what is the marketing mix, which product-market strategy is followed.”**

(Timmers, 1998)

Around the academic development of the “Business Model Canvas”, there has also been the development of a number of tools that take the manual methodologies developed by Osterwalder & Pigneur (2010) and codify them into digital applications that add value through prompts and automation. These produce graphically nice outputs, prompts for thinking and aids to usability; however, the diagrams in this thesis have been constructed using manual methods as these new tools were not available when the research was embarked upon. However, they are increasingly being adopted by practitioners as they seek to engage with ‘Business Model Design’.

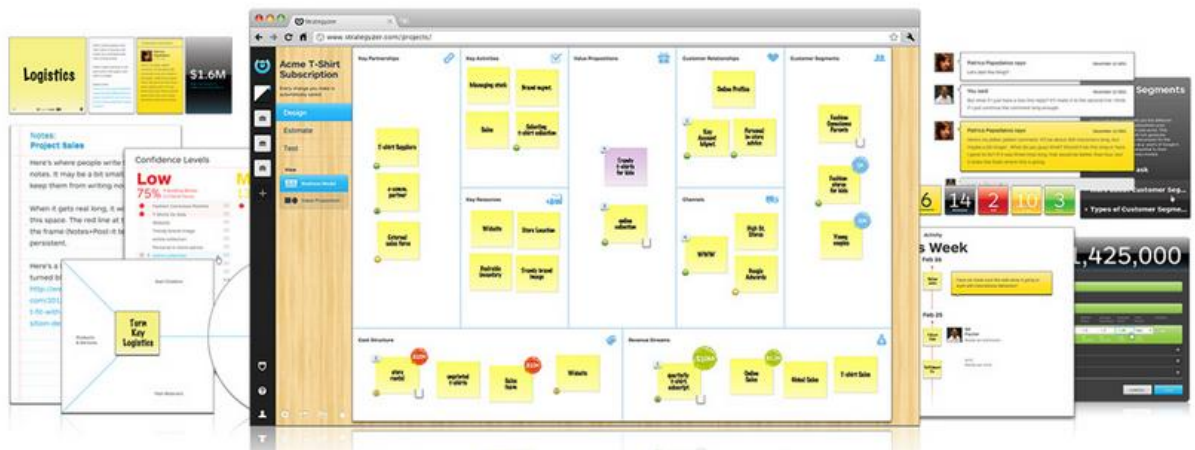


Figure 31 - Screenshots from Business Model Innovation Software “Strategyzer”

### 2.5.7 Business Model Design

'Design thinking' is, at work, when humans create something. Whether it 'consciously' or 'sub-consciously' applies any process, structure or methodology or not, the act of creation involves design and the concept of 'design' can apply to any number of domains (Lawson, 2005, p. 108). Before the term 'business model' became *en vogue*, individuals were still busy fashioning money-making schemes, enterprises and businesses. To use an analogue, man still made furniture and useful tools to fulfil functions in a time before the process of design was formalised and understood. However, arguably understanding the process of design brings structure to intuitive processes (Lawson, 2005, p. 4), and through achieving mastery of the process of design, the result is a finished artefact, process, or indeed a business model with enhanced attributes.

***“Before the personal computer changed the nature of business planning, most successful business models, like Fargo’s\* were created more by accident than by design and forethought”***

\*Fargo created the American Express Traveller’s Cheque

**(Magretta, 2002)**

Osterwalder & Pigneur dedicate a substantial section of their work, 'Business Model Generation' (2010, pp. 124-199), to the topic of 'design'. They open the section with a quote from Roger Martin, Dean of Rotman School of Management *“Businesspeople don’t just need to understand designers better; they need to become designers”*. (Osterwalder & Pigneur, 2010, p. 124). This point is echoed by Teece (2010, p. 173) *“understanding business design options as well as customer needs and technological trajectories”*

However, business model designs are not just about the aesthetic or feel of a business, but the underpinning commercial logic for how the business operates. Magretta (2002) states that *“Business modelling is the managerial equivalent of the scientific method- you start with a hypothesis, which you then test in action and revise when necessary”*. This scientific approach moves beyond accountancy though; Teece (2010, p. 173) *“a business model [is] a conceptual, rather than financial, model of a business”*

### 2.5.8 How are Business Model Decisions Made In Firms?

New business models can come from old firms seeking to re-invent themselves. However, they can also come from new insurgent firms. Günzel & Krause (2013) explore the role of the business model in new venture creation. Later in this section, ‘Change Models’ (see page Figure 33 - Change Models - from (Linder & Cantrell, 2001, p. 13)108) are explored, as one way of explaining how old firms re-invent themselves with new business models.

Foss & Stieglitz (2014, p.3) contest that there is a lack of information regarding the “leadership aspects” of business model innovation. With new startups, there is perhaps a clearer understanding of who is driving business model innovation – however, in established firms with distributed power making structure who leads change?

In a similar vein, looking at decisions to innovate Meertens, Starreveld, Iacob, & Nieuwenhuis (2013) have written on the subject of a business case development methodology to compare potential innovations within the business, and decide on an appropriate path. They consider the three possible types of innovation as “strategy innovation”, “business model innovation” and consider “product and process” innovation as one. The perspective in this thesis takes a slightly different view, separating product and process innovation, but conflating strategy and business model innovation into one and the same thing. Where Meertens, Starrveld, Jacob & Niewenhuis (2013) advance the field, is in categorising the degree to which decisions about business model direction can be categorised as “objective”; based on hard facts and data, or alternatively are “subjective decisions”. It is perhaps unsurprising that a great deal of the decisions that go into business model selection are highly subjective.

<b>Method step</b>	Objective / Subjective
<b>Business driver</b>	Objective
<b>Business objectives</b>	Objective
<b>Identification of alternatives</b>	Subjective
<b>Effects</b>	Subjective
<b>Risks</b>	Subjective
<b>Costs</b>	Objective
<b>Alternative selection</b>	Objective / Subjective
<b>Implementation plan</b>	Subjective

**Table 11 – Assessment of the Objectivity of the Business Case Method**

### 2.5.9 New Business Models

One of the threads that runs through the business model literature is that, by configuring the business logic in a different way firms can obtain competitive advantage. For new firms, challenging through points of difference may be straightforward. However, for incumbents this process of reconfiguration comes with risks attached (Pateli & Giaglis, 2005 citing Kalakota & Robinson, 2001). That said, there is equally risks associated with standing still and not innovating (Malholtra, 2001) as “*best practices’ turn into ‘worst practises’ and ‘core competencies’ turn into ‘core rigidities’*” Linder & Cantrell (2001, p. 2) have said that firms need to “*master the ability to change their business model—again effectively—at a pace that matches the dynamism in their markets’*”

Govindarajan & Trimble (2011) implore managers to think about "Business Model Innovation" and their organisations vulnerability to business model evolution in terms of 'three boxes'. This analogy provides a useful abstraction through which the problems facing the car industry can be viewed.

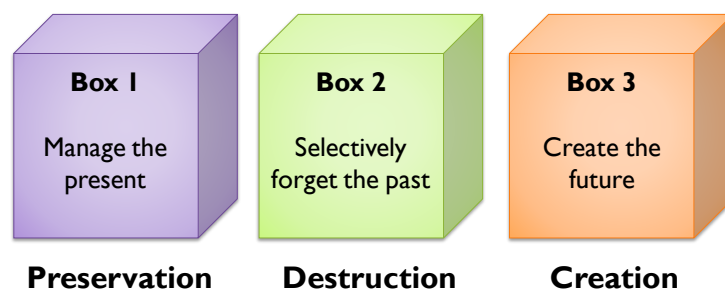


Figure 32 - "Three Boxes" Approach To Business Model Management proposed by (Govindarajan & Trimble, 2011)

Their approach, Govindarajan & Trimble, (2011), is to consider internal projects within an organisation and sort them into the three boxes shown in the above Figure. This should be done with due consideration given to the forces acting on an industry, with as much foresight as can be reasonably mustered. They argue strongly, that there is a preoccupation with preservation; 'Box 1' initiatives. Whilst insufficient attention is paid to '*stopping [...] underperforming products and services, obsolete policies and practices, outdated assumptions and mind-sets*' which they label Destruction ('Box 2') and preparing organisations for the long term, the 'Box 3' creation initiatives.

There is an attachment to tried-and-tested practice in any industry, as these practices represent stability. This presents a challenge for the automotive industry, indeed any industry that creates a great deal of customer value through building strong and robust brands. Brands require a high degree of stability in order to meet existing customer expectations (Motameni & Shahrokhi, 1998; Gartner, 2009; Simon, 1993), but, at the same time, firms need to be able to meet current market expectations.

Hamel (2000) describes the challenges that arise when business models become outdated.

***The old business models have now reached the point at which they begin to see their marginal productivity drop inexorably. Their strategies, which focus on cost reduction procedures such as downsizing, restructuring, outsourcing, etc., have become indistinguishable from those used by their competitors. Initially, this process enabled margins to be improved but the time came when no progress could be made any longer.***

---

(Hamel, 2000)

So, it has been established that whilst there are expectations on firms to provide consistency and stability, there may also come a point at which a firm's business model may need to adapt to a changing environment for the firm to remain successful.

There is a temporal dimension to business models the business model, but not all 'ontologies' of the business model concept capture that dynamism. In capturing a 'snapshot' of an organisations business model at one stage in time, it is unrepresentative of the changing dynamic nature of the model and the firm's "success often depends on management's ability to tweak, or otherwise, on the fly" (Magretta, 2002).

Here, the challenge is in the variety of definitions of business model. Some conceptualisations of the 'business model concept' capture change, others do not. In the 'Business Model' description itself, as embodied by Osterwalder's (2004) ontology and the 'business model canvas' classification there is no description of how the business logic might change over time. Accepting Osterwalder's (2004) description of what constitutes as business model, then there is the need for 'something else', a distinct concept, to describe how that business model might change over time.

The planned evolution of business models over time is what Linder & Cantrell (2001, p. 1) refer to as 'change models', however, some other authors (Pateli & Giaglis, 2003) refer to the planned change of business models as 'business model evolution'.

The latter term, is problematic, as 'change model' sounds like something deliberate and planned, whereas 'evolution' sounds like a more spontaneous process that emerges from the businesses adaption to its changing environment.

Here, there is perhaps a gap in the literature; as business models change, to what degree is that change planned? Is the change planned 'centrally' – as might be the case in a top-down hierarchy, or is that change an 'emergent' evolutionary property from 'bottom up' interactions

If this process is planned and managed, it can be a source of competitive advantage, as it is controlled– rather than forced at a crisis point.

***Leading companies don't just adjust their business models incrementally, however, they master change models. Heads-up managers know how business models evolve, they know where they are in the process, and they deliberately manage patterns of change.***

---

(Linder & Cantrell, 2001, p. 2)

Linder & Cantrell (2001, p. 10) define change models as “the core logic for how a firm will change over time to remain profitable in a dynamic environment”. These models are interesting, when considered through the transitions lens of 'regime adaptation', and potentially there are links that can be drawn between this theory of change, and transitions models of regime change.

They define types of change model firms can adopt:

Change Model	Description
<b>Realisation Model</b>	Realisation models keep the businesses 'existing operating logic' the same, realising all the value possible from the current business model. It represents the least change in all of the change models presented.
<b>Renewal Model</b>	Renewal business models refresh companies existing product and service offerings by refreshing 'brands, cost structures and technology bases' to counteract competitive forces in the marketplace.
<b>Extension Model</b>	Extension models are used to expand upon an existing business model in order to reach into 'new markets, value chain functions and product and service lines' The extension 'complements' existing product offerings rather than replacing them.
<b>Journey Model</b>	Companies move 'deliberately and purposefully' to new ways of working and configuring their business model with the aim of never returning to their former configuration.

Table 12 - Summary of change model characteristics; compiled from (Linder & Cantrell, 2001, pp. 10-13)

Linder & Cantrell (2001) also represent these change models graphically:

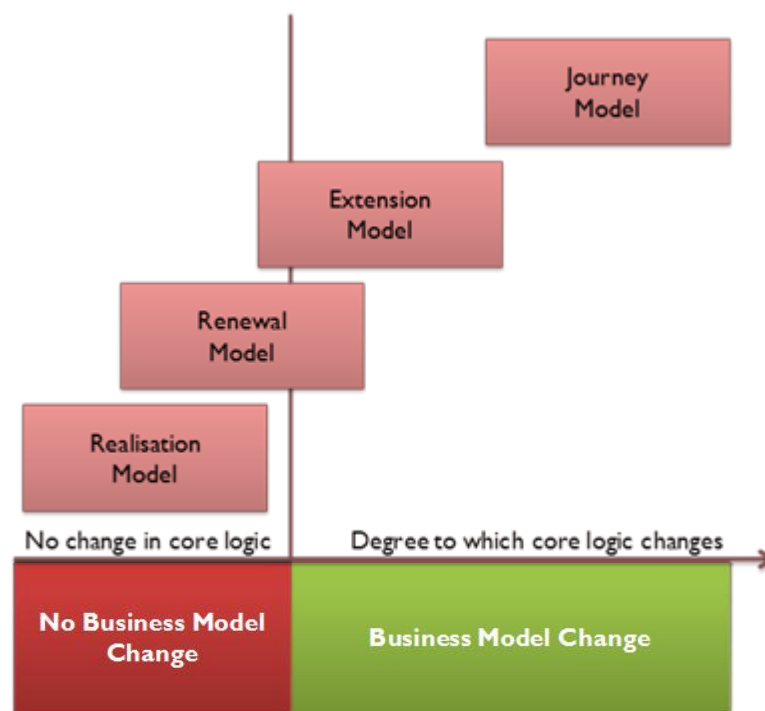


Figure 33 - Change Models - from (Linder & Cantrell, 2001, p. 13)



### 2.5.10 Business Models for Sustainability

Wells (2013, p. 3) differentiates between the concepts of ‘Sustainable Business Models’, and ‘Business Models for Sustainability’. Here, it is noted that, with the former, phraseologically there are questions as to whether the underlying logic of the business model is just to sustain itself i.e. to endure at any cost. This thesis concerns itself with business models that contribute to the discourse, journey and perhaps accomplishment of sustainability, and therefore, it adopts Wells’ (2013, p. 3) terminology of Business Models for (that is to say in the service of) Sustainability.

If Business models are to be designed in the service of sustainability, then how are these business models represented abstractly? In this thesis, the view is taken, that the standard business model canvas proposed by Osterwalder & Pigneur (2002) provides snapshots that are comparable of both ‘green’ and ‘dirty’ enterprises. Appraising the sustainability of enterprises is so challenging and subjective, that no attempt is made in this thesis to do so, instead relying on narrative accounts of the potential benefits and disadvantages of various approaches.

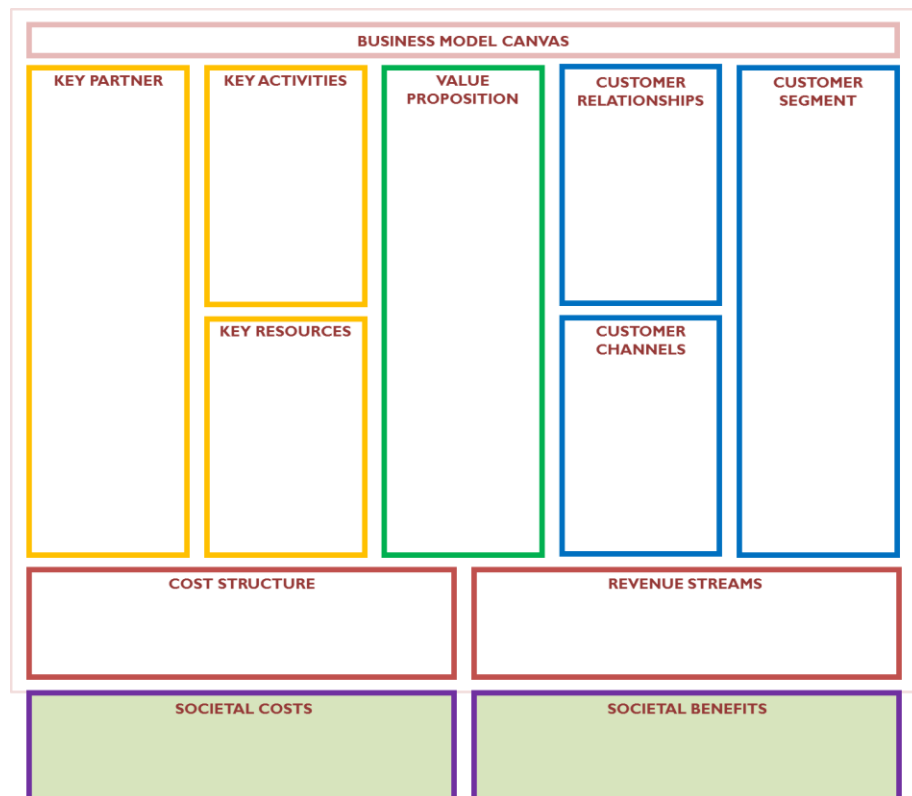


Figure 34 – Business Model Canvas – With Societal Accounting

If the ontology were to be modified, how might our abstract conceptualisations of the business model take account of these social costs and impacts? The business model canvas on the previous page has been advanced by Studio Spark (2012) as one potential solution.

Why is there the need for business models *for sustainability*? There is a “*discrepancy between private and public benefit (and cost)*” (Wüstenhagen & Boehnke, 2006) in switching to sustainable technologies. They may result in “*reduced environmental impact, however, does not necessarily translate into reduced private cost for the consumer, because the environmental externalities of conventional energy systems (such as the damages caused by CO2 emissions [...]) are not fully internalized in market prices. Therefore, switching [...] means lower cost to society, but not necessarily lower cost for the consumer.*”

What is the motivation for corporates to engage in business models for sustainability? In their report, ‘The Business of Sustainability’, The Boston Consulting Group identified that “*Once companies pursue sustainability initiatives in earnest, they tend to unearth opportunities to reduce costs, create new revenue streams, and develop more innovative business models.*” (Berns, et al., 2009)

Wüstenhagen & Boehnke (2006) offer further insight into how to best create sustainable business models, “*by focussing the **VALUE PROPOSITION** on the aspects that create the highest (private) customer value, rather than primarily highlighting the public benefits of sustainable energy, is a means to address the challenges posed by environmental externalities.*”

Here there are two separate, but interlinked problems about how to deliver a sustainable value proposition to consumers. On the one hand, the technologies used to create that value for consumers may need to change. This may involve changes to the way that value is created within the business.

On the other hand however, there is a need to transition to more sustainable methods of capturing the value from consumers. This perhaps is the even more challenging transition to accomplish as it requires not only technological substitution, but also widespread changes in culture.

### 2.5.11 Business Models & The Automotive Industry

In the automotive sector, there is also the challenge that automotive brands are built on the attributes that their vehicles espouse. Kitchin, (2003) states that it is “*brands that mediate the promises of the organisation*”; Govindarajan & Trimble (2011) account for this preoccupation with short-term pressures noting that “*many companies become too focused on executing today's business model and forget that business models are perishable*” and he notes the importance of an ignorance of longer term risks that stem from the failure to transform and reinvigorate their business models, adding “*success today does not guarantee success tomorrow*”. Indeed, it is questionable even if the automotive industry as it stands is even enjoying “*success today*”.

The automotive industry is heavily affected by the economic cycle, (Wengel, Warnke, & Lindbom, 2003, p. 2) with the trend being that the production of cars is affected even more heavily during a recession than other manufacturing sectors. Today's automotive industry bears the scars 2008/9 international financial crisis which “*witnessed the demise of corporate giants and unprecedented government responses*” (Walters & Newton, 2010, p. 2). Given that, combined with the political will of governments to see progress towards sustainability, it is perhaps surprising that the private sector has not rapidly mobilised “*creative and profitable alternatives*” (Vergragt & Brown, 2007) to conventional automobility.

Traditional motor vehicles are relatively cheap to produce; using the techniques of mass production and pressed steel bodywork, to produce a uniform product. Looking at the costs of running a traditional motor vehicle over the life-cycle of the vehicle; the purchase price of the vehicle is relatively low. Taking an environmental costing view of traditional vehicle technologies, the conclusion could be drawn that the low monetary purchase price of the vehicle is offset by high environmental and social costs, which is borne by society collectively as a result of environmental degradation.

Over the lifetime of the vehicle, the costs of repair and maintenance are rather high – traditional vehicle technologies require a range of service parts to be replaced periodically – oil, oil filters, air filters, clutches, timing chains and belts,

Furthermore, the cost of delivering the energy to provide automobility is also high - consuming finite fossil fuels which seem likely to increase further in cost as steadily diminishing reserves are fought over by an ever growing and affluent global population.

That said, there is a question to be asked about the role of governments in sustaining the unsustainable. It has been argued by Wells & Orsato (2004, p. 373) that business models are a neglected aspect of policy making when attempting to effect transformation of the automotive industry. Wells P. (2010b, p. 305) has argued that there is *'considerable scope to dismantle existing barriers to entry to the sector and for new entrants to unleash innovative business models'*

Friedman (2008) has asked the question, whether it was the right thing to do, propping up the auto-industry's unsustainable business model. He likens the move to like *"pouring billions of dollars into the CD music business on the eve of the birth of the iPod and iTunes. [...] pouring billions of dollars into a bookstore chain on the eve of the birth of Amazon.com and the Kindle [or even like...] pouring billions of dollars into improving typewriters on the eve of the birth of the PC and the Internet."* Similarly, Boundreaux (2011) *"Bankruptcy doesn't make assets — such as factories, machines, contractual options to buy raw materials, workers' skills — disappear. If markets still exist for products produced by these firms, Chapter 11 is the best way to discover this."*

Wells P., (x2010b, p. 305) argues that the *'automotive industry has reached the end of a prolonged period of technological monoculture'*, arguing that the future will be *'one characterised by technological diversity in which the solutions for automobility will vary according to spatially-specific requirements, embedded capability and strategy'*

Furthermore, it is important to cast what may have been perceived as a crisis for the established industry, as an enormous opportunity for insurgent businesses. Wells & Orsato (2004, p. 374) point to the *"failure of the traditional automotive business model in 'capturing a high proportion of the lifetime revenue stream created by a car in use'"*

That said, the business models of the alternative future are not understood. As Beaume & Midler (2009) highlight in identifying a number of challenges electric vehicles face note that there has been a failure to address the 'Business Model of an EV roll-out'. *"Appropriately designed business models are an important opportunity to overcome some of the key barriers to market diffusion of sustainable energy technologies."* (Wüstenhagen & Boehnke, 2006)

Many disruptive vehicle technologies will require a radically different support infrastructure from current sustainable automotive solutions. Electric vehicles will require a recharging network which can support the charging of large numbers of electric vehicles without deleterious effects to the grid and power quality; whilst also requiring opportunities to plug in and charge up in convenient places. The way these services are used and consumed will also differ from conventional vehicles – a five minute fill at a petrol station every half thousand miles, may instead be replaced by the need to recharge for longer; whilst also needing to recharge more frequently.

Fuel cell vehicles also present many challenges – their recharging system being different again, requiring a production, distribution and storage infrastructure for hydrogen.

The key point here is that no amount of technological innovation would result in a solution to this seemingly intractable problem,

These challenges are not unique to automotive sustainability. In many domains of sustainable technology development; there is a need for infrastructure development in order to support the realisation of sustainable innovation. The lessons drawn from the automotive industry are therefore widely applicable to a variety of other fields of application.

One of the challenges of innovation is that it is characterised by uncertainty, which is highest in the early stages of innovation and reduces over the product lifecycle (Klein & Rosenberg, 1986, p. 284). Casadesus-Masanell & Ricart (2011) note that business model decisions, involve choices which in turn have consequences.

### 2.5.12 Risk & Innovation in Vehicle Innovation

ULEVs are innovations, which, dependent on the technology type, are at various stages of technology readiness (Leighty, Yang, & Ogden, 2008). ICE vehicles, by contrast are a relatively risk free proposition for VMs, the technology is understood leading to low uncertainty in this dimension, **CUSTOMER SEGMENTS** willing to purchase vehicles are understood as well as the established **CUSTOMER RELATIONSHIP** between vehicle makers, their brands and the marketplace the **CUSTOMER CHANNELS** through which vehicles are sold are well established.

Furthermore, consumers are accepting of ICE vehicles as the **VALUE PROPOSITION** is familiar, and the infrastructure and processes used to produce these types of vehicle i.e. the supply chains **KEY PARTNERS, KEY ACTIVITIES,** and **KEY RESOURCES** are all well established. Some of these aspects correlate to technical uncertainties, others, such as **COST STRUCTURE** and **REVENUE STREAMS,** to commercial ones. By contrast, with ULEV technologies, there is greater uncertainty. Some of this uncertainty arises from consumer perception, some from technology development and some from the commercial awareness. In Figure 35 below, some of the dimensions of this uncertainty can be seen; it is an illustration that both technical and commercial innovation present their own risks, and that, in combination, there are serious challenges to surmount, but potentially great rewards (Wells P. E., 2013, pp. 28-30).

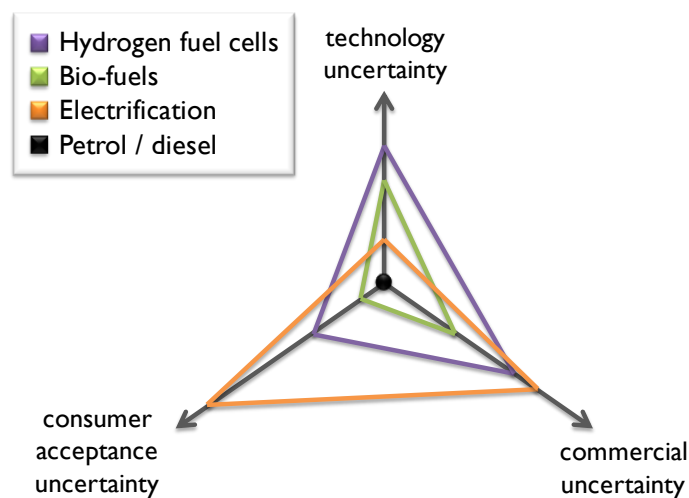


Figure 35 - Uncertainty associated with developing alternative vehicle technologies. From: Clarke (2009)

### 2.5.13 Criticisms of the “Business Model’ Concept

Throughout this chapter, some of the challenges of an emerging field of literature have been exposed. In particular, the recurring criticism, that ‘business models’ lack definition. Aside from this, there has been some quite direct criticisms of the business model field. Arend (2013, pp. 391-392), in suggesting future directions for the ‘business model’ concept, provides a summary of some of the existing critique of the theory. Some of this inevitably stems, from the variety of ways in which the term “business model” is interpreted and codified by different authors. Taking for example Arend’s (2013, p. 392) characterisation of an ‘extreme’ critique of the business models concept: “*On one (extreme) hand, it could be argued that the idea of the business model has been yet another un-needed re-labeled re-interpretation of the profit equation in search of some distinction as a new level-of-analysis.*” – could this same critique be applied to a characterisation of the business model such as Osterwalder & Pigneur (2002)? Not all agree with Arend’s characterisations of the deficiencies of the Business Model concept. Zott & Amit (2013, p. 406) respond sequentially to each of Arend’s (2013) criticisms. One, is particularly useful to highlight – and helps build the case for the integration of business model theory, with that of the transitions theory (which this thesis attempts to do on p.119). Arend (2013, p.392-393) contends that Business Model analysis does not constitute a unique level of analysis – overlapping with other concepts – however, Zott and Amit’s (2013, p406) rejoinder, is that business models differ from firm-level analyses, by providing an intermediate level of analysis between the firm and the network. Their response to Arend’s (2013) critique is reprinted in full, as it provides ample justification for the theoretical approach that this study employs by seeking to integrate the business model into a multi-level analysis as provided by transitions theory.

***It is centered on a focal firm, yet spans focal firm boundaries by including stakeholders with which the firm interacts when it produces and delivers value. As such, the business model is linked to other levels of analysis, although it is distinct. The fact that the business model links to other levels of analysis and relates to notions of entrepreneurship and design is not a problem per se. It rather points to the need to conduct multi-level research and to integrate theoretical perspectives, as we have long advocated (Amit & Zott, 2001).***

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Zott and Amit’s (2013, p406)

Arend (2013, p. 392) concedes that there is potential application for 'business models' in forming a common language through which to formulate descriptions of businesses. As an *integrative* term, it serves to reduce complexity (Arend, 2013, p. 392). So far so good, although perhaps it would not be unfair to raise objection at Arend's barb that, as a practical tool, business model descriptions serve to create "*coherent stories for the cognitively limited participants involved*".

Arend at least acknowledges one of the most positive aspects of the business model concept, in that he states that it has engaged both the academic and practitioner community alike, and has served as a *lingua franca* for communication between the two. Tapp (2005) has argued vociferously for crafting academic knowledge in such a way that it is useful to practitioner communities. Whilst Arend (2013 p.293) may contest that the 'business models' concept involves some re-hashing of previous theory, if it does so in a way that makes it accessible to a community of practice rather than distant removed and academic, is this necessarily a fault? Tapp (2005, p. 9) cautions against "*falling into a collective stupor, questioning the fiddly details, but failing to question the fundamentals*"; after all, what is the contribution of the research? The high levels of commercial engagement with the business models discourse is arguably one of its great successes.

Whilst there may be discord over business model definitions, and whilst there may be imprecision in their use and application, do alternatives which provide the illusion of precision offer any real improvement? As Tapp (2007) has said, "*...the quantified models that dominate marketing journals go too far. They impart an impression of precision that is largely an illusion, and is damaging our discipline by making us irrelevant.*". in addition, "*Common sense is forgotten: as we become better and better statistical technicians, we get worse and worse at developing commercial acumen.*" Tapp (2005, p. 10)

Later, in (p.174) the case is argued for using a research approach of 4.7.2 Engaged Scholarship (p.192). It is an approach which answers many of Tapp's (2005) calls to make research relevant to practitioners. This approach is not without it's critics (examined on p.195).



## 2.6 Research Gaps Identified

Through this exploration of the literature, the following six research gaps have been identified.

Some of these gaps relate to theoretical shortcomings, where there is a perceived need for linkage between theory. Other research gaps relate to a lack of empirical work focusing on the UK car industry. These inform this thesis' six research themes, which collectively answer its' central research question.

### **What Is The role of Business Model Innovation in Ultra Low Emissions Vehicles transitioning To Market?**

The research gaps that have been identified are:

1. There is a lack of theoretical linkage between the Business Model literature and the literature on Technological Transitions. As the Business Model explains the operating logic of the firms and, as firms are niche actors within the transitions process, it should be relatively straightforward to link these two literatures cogently. In the next section, "Linking the Theory Base for the Research", it is proposed how these literature might integrate. The empirical study seeks to provide some validation for this proposed linkage.
2. Whilst the current literature on business models in the automotive industry have been explored, in the UK context specifically, there is a lack of a systematic and comprehensive study that examines what types of business exists in the marketplace. Furthermore, different approaches are used in the discussion of business models. Through applying a consistent approach, The Business Model Canvas, discussed in the Methodology, it should be possible to make more meaningful comparisons.
3. Whilst there are already a number of studies examining Business Models in the Automotive Industry, there is not a comprehensive account of what models , and also what innovative components of business models are in use in the UK national context. This thesis seeks to

collate and present, as far as possible, those innovative 'Business Model Components' that can be found in the UK automotive industry.

4. There are already many well identified 'Transition Pathways' and those sources have been explored within this review. These transitions mechanisms have been identified through case studies of different industries and sectors. This thesis builds on the empirical studies that contribute to the body of transitions literature. It is presupposed that there are more transitions mechanisms that have not yet been identified and can be discovered. However, perhaps more interestingly it has also been argued that there is a need for understanding why transitions do not occur.
5. Within the Innovation literature, there is significant debate about the sources of innovation from both established firms and/or insurgent firms. It is believed that the Business Model Perspective may be able to contribute fresh ideas to this particular debate. To what degree could an understanding of 'Business Models' embedded within an understanding of the 'Transitions Framework' help to understand the relationship between niches, and incumbents in better detail?
6. The relationship between vehicle design and the design of the processes used to produce vehicles is well understood. The process of Business Model Design has also been well explored within the academic literature. Where there is a gap, is in understanding, from a design process point of view, how 'product design', 'process design' and 'business model design' is carried out by different firms. (Since this research process was initiated, some contemporary research by Meertens, Starreveld, Iacob, & Nieuwenhuis (2013) has begun to work in this area – however, this work presents another perspective on this problem.

## 2.7 Uniting the Theory Base for the Thesis

Figure 36 is an attempt to graphically unify the theory base for this research, it is explained overleaf.

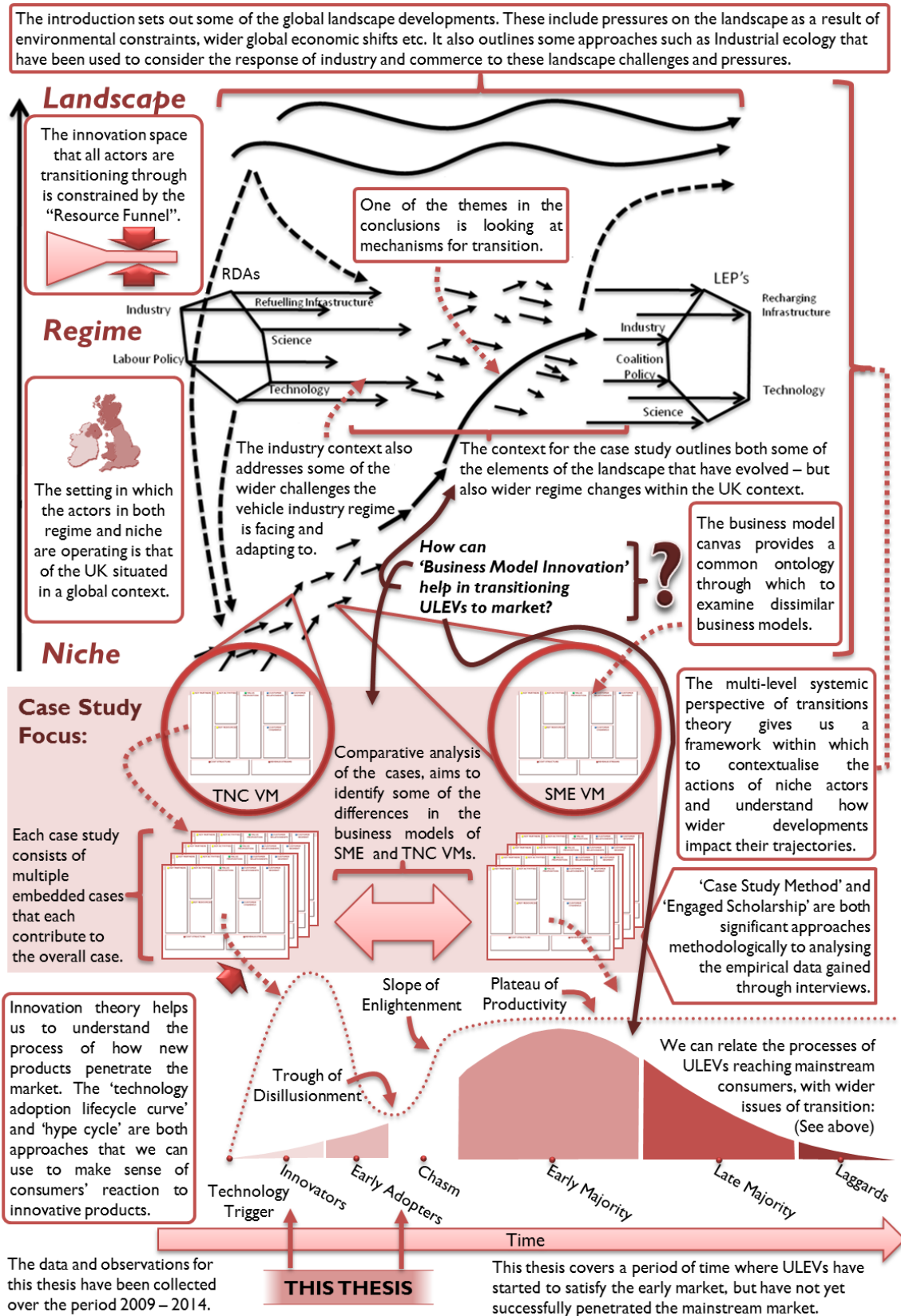


Figure 36 - A Visual Map of the Thesis  
Drawing on: (Geels F. W., 2002; Osterwalder & Pigneur, 2002)

The main research question is shown centrally alongside the brace and question mark, with the dark maroon arrows relating to elements of the question and to sections of the diagram.

Starting at the bottom of the image and working up, the image is explained. The candidature, during which this research was undertaken, took place over an extended period of 2009-2014 (as a result of exogenous factors). Whilst the candidate's nerves and university administrator's patience may not have benefited from this extended period during which observations were conducted, the research ultimately has. The study never set out to be "longitudinal" in nature, originally setting out to be a "snapshot" of an industry in the time that was available, however, the extended period of analysis has given a more rounded perspective on the study. Of particular interest has been the dynamics of smaller companies where, during the candidature, companies have folded, acquisitions have been made and some innovative business models which have showed great promise continue to show great promise, despite having made little progress towards their business goals.

Throughout the thesis, the temporal dimension is particularly important to consider throughout, as it examines a process of 'transition' which has been on-going for some time and will continue to take some time to reach its ultimate fulfilment. Whilst it is impossible to establish with certainty and precision, it is important to consider the position of the thesis in relation to this.

This thesis has already taken a very brief view of innovation theory in the literature review, by examining the process of bringing new products successfully to the market. This thesis will delve into this theory in greater depth. ULEVs can be seen as a product being brought to market, although it is important to note that, whilst the thesis looks at ULEVs 'collectively', references made to ULEV' are, in fact, referring to a basket of different technologies which may reach market maturity at different points in time. The general scheme of the Technology Adoption Life Cycle model aims to show that the thesis construction took place during a period where most ULEVs were being purchased by innovators and early adopters. Geoffrey Moore introduced the concept of "The Chasm" i.e. a tricky point of transition between an 'early market' fuelled by enthusiasts for the technology and the later 'mainstream' market where the technology gains more widespread acceptance. Here, some distinction

might be offered between the various technologies: Arguably technologies such as Hybrid vehicles are just starting to reach the point of gaining more widespread consumer acceptance, and so it is not such a dramatic leap from a hybrid to a 'plug-in' hybrid, which would be considered to be in our basket of ULEV technologies.

By contrast, other ULEV technology types, such as electric vehicles, are still some way off reaching more widespread acceptance but are starting to reach consumers in significant number. At the opposite end of this scale is Hydrogen Fuel Cell vehicles, which show much promise for the future but have not reached the market in any great numbers globally and, where they have they are deployed, has been in isolated regional pockets, notably California.

Alongside the Technology Adoption Lifecycle Model, there is also a line representing "Gartner's Hype Cycle". This captures the way in which society and the media interact to create an inflated expectation of a product's features in the early stages of its deployment, leading to disillusionment later on. As a more realistic assessment of the new technologies capabilities is made, products develop in their sophistication and more consumers are familiar with the product, this 'trough of disillusionment' gives way to a 'plateau of productivity' where the product gains more mainstream acceptance of the product.

If that section of the image captures the essence of the "Product Innovation" literature which features highly, then the very top of the image positions this product innovation in the context of wider systemic change.

The transitions literature, with its Multi-Level Perspective, places product innovation and innovative niches, within the context of wider socio-technical change. Indeed, this is an important perspective, as ULEV vehicles will require substantively different industrial ecologies to support their widespread deployment. The transitions framework relates changes in the wider landscape to the dynamics of the regime that is under analysis.

One of the crucial interactions is that between regime and niche. It is the niche actors that are engaged in the process of innovation, and trying to bring transformative products to market.

In this case, 'firms' are the 'niche actors' which seek to deliver sustainable innovations, namely ULEVs. They may also be engaged in trying to champion 'new mobility concepts'; this by challenging consumers perception of what constitutes a 'vehicle', by changing the product, or by delivering the 'service' of automobility in a different way – e.g. car-sharing via an app or through a product service system.

Here, the “Business Model” provides an understanding of firms' core operating logic. It provides a systematic way to interrogate and compare the business models of widely differing firms in a manner that is scale neutral. Thus it allows comparisons between industrial giants with smaller businesses that may be small but nevertheless are engaged in the same challenge.

Within what is termed as 'SME VMs', there is significant variation in the size of enterprise. There are many challenging questions of scale and, in delineating between the two case studies of 'TNC/MNC VMs' and 'SME VMs', there are challenges in assigning embedded cases to one group or another.

There is a paradox in that, whilst many of the SME VMs have come to market with much more ambitious product offerings and some with radically different business models, the net improvement in the sustainability of private mobility is likely to be small because of the fractional market share of these companies.

Indeed, it is an interesting observation of the UK marketplace, that the five most popular vehicle manufacturers (Ford, Vauxhall, Volkswagen, Peugeot and Renault) dominate the marketplace, accounting for almost half of the licensed vehicles in Britain at the end of 2009 (Department for Transport, 2010).

What is the way ahead if vehicle manufacturers are to rise to the challenges posed in the introduction and context? Inevitably, there will be some concatenation of the business models exhibited by large TNC/MNC VMs and smaller SME VMs. Larger concerns may choose to acquire elements of smaller companies capabilities through acquisition and, in doing so, may take on board more radical elements of their business models as part of an evolution of their own business models. They may instead attempt to change their own business models, emulating the examples shown by more radical firms.

## 2.8 Chapter Summary

This chapter provided an exploration of several fields of academic literature which were seen as being relevant to the problem of introducing Ultra Low Emissions Vehicles to market. The chapter opened by exploring the nature of technological continuity and change. This theme explored why some technologies endure, and how technological change may occur. This was rooted in the context of the automotive industry, whose business model and technology base has remained stable and resistant to challenge. The literature around 'socio-technical transitions', discussed in the next section, built upon some of those themes. Here, the concept of 'socio-technical' systems was introduced. If this provided a frame for the broader context of industry transition, the section that followed began to look at technological innovation more specifically, providing an overview of the 'innovation' literature and also looking at eco-innovation and technological change.

If these first two sections are considered to provide a 'macro' view of industries in transition, then the following section 2.5 begins to look at the 'micro' level of the firm. The Business Models literature is seen as a vehicle for understanding the business logic of firms. The concept of 'Business Model Innovation' identified as a distinct concept from technological innovation.

Chapter Two provided the theoretical underpinning for the empirical work of the thesis. In section 2.6 gaps in the extant literature were identified. Section 2.7 looked at linkages between these separate fields of literature and drew them together into a coherent whole, forming the theoretical basis for the empirical work conducted in this thesis.

Chapter 3 goes on to build upon this theoretical work, by relating one strand of the literature review, 'Business Models' the central theme of this work, to the automotive sector.

## Chapter 3:

### **Practical Basis for the Research: Business Models & Innovation in the Car Industry**

This thesis can characterise the vast majority of the vehicle marketplace as coming from manufacturers that could variously be described as “mainstream”, “dominant” or “traditional”, with their business model considered to be the ‘*dominant archetype*’. Within the academic literature, there are a range of different accounts of the historical development of what is widely understood to be the automotive industry’s business model. These debates are very relevant to the understanding of the present car manufacturing system. To understand the business model that prevails in the industry, it is important to see how that model has been shaped, the forces that have shaped it and its evolution.

However, the dominant model employed by the majority of the industry is not the only model for producing vehicles. There are, of course, a plethora of different business models that companies use to bring motor vehicles to market. The issue of scale is explored throughout this thesis; the business models used by smaller manufacturers to bring vehicles to market are radically different from volume manufacturers. That said they occupy only a fraction of the marketplace. Although their market share may not be great, they have other features that make them of interest. There are more models still, which exist in the minds of entrepreneurs and are, as yet, unrealised. In time, these different models of car manufacture and consumption may have the potential to both enter and potentially conquer the marketplace or, alternatively, elements of these models may shape the dominant industry practices.

This chapter accounts for current practice and examines the pressures that the dominant archetype of the automotive business model faces. In later sections, this thesis turns to the subject of smaller manufacturers attempting to realise the same challenge of bringing vehicles to market, albeit with more constrained resources. Finally, the chapter examines ‘radical’ business models which differ dramatically from the status quo and have elements which could potentially be used to recast the industry in a more sustainable mould.



### 3.1 The Mainstream Car Industry

The traditional automotive industry's business model has undergone incremental evolution for a number of decades. Perhaps it is this process of constant refinement of the industry's business model that has resulted in what academics term *institutional isomorphism* (Wells & Nieuwenhuis 2012); that is to say, the business models used by the large players in the sector exhibit a strong degree of homogeneity. The profitable production of motor vehicles has relied largely on a stable technology formula of pressed steel body work and the internal combustion engine; two technologies that lend themselves to large scale and centralised mass production.

Whilst the social and environmental sustainability of current vehicle technologies is open to question, more recently, the once profitable automotive industry has had to question the economic sustainability of its operations. *"Recent crises at [Ford, GM, Chrysler] combined with the collapse or near-collapse of many of their major suppliers have undermined this dominance and have led to a questioning of the business model that underpins it."* (Nieuwenhuis P. , 2012, p. 18). Furthermore, there is an imperative to develop new technologies which will enable a cleaner, greener conception of automobility.

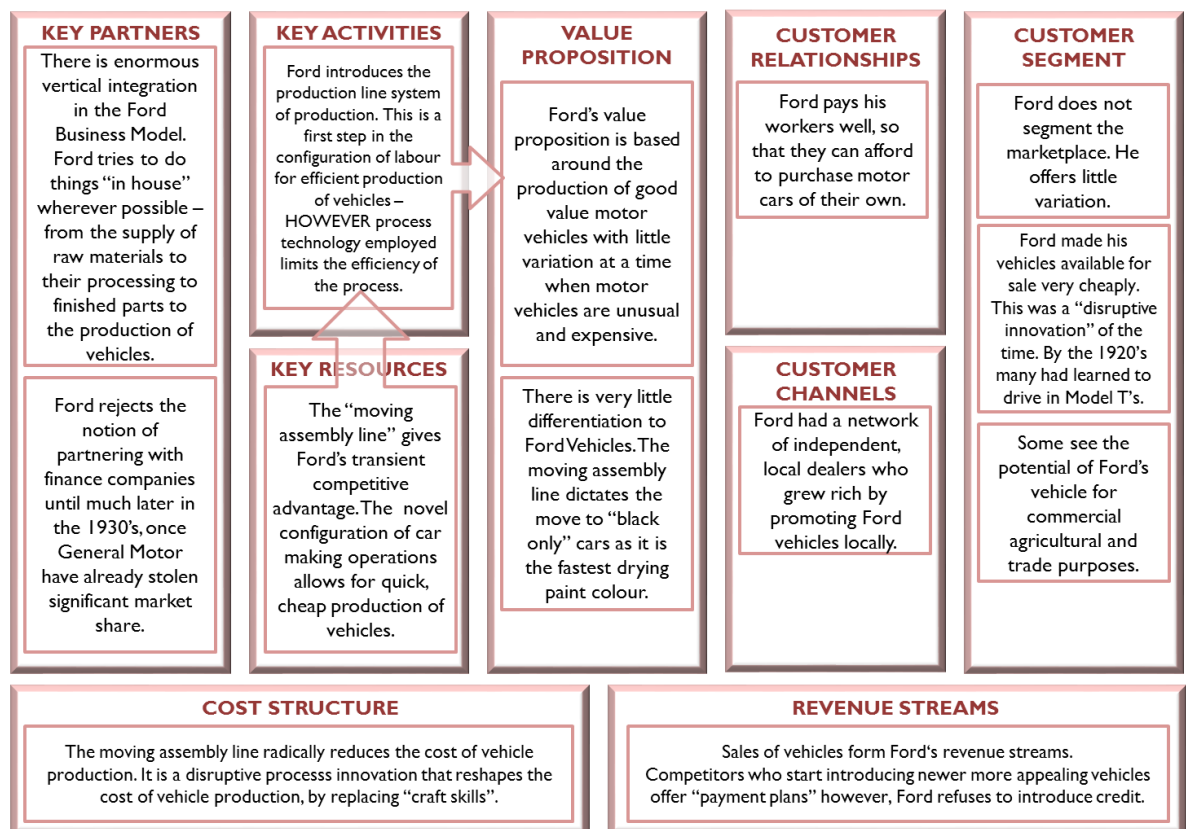
Most manufacturing of motor vehicles is undertaken by large companies (Wengel, Warnke, & Lindbom, 2003, p. 3); indeed the world's three largest companies in 1998 were all car manufacturers. These manufacturers tend to follow a range of relatively conservative business models focused on centralised production, economies of scale and selling the product to consumers. Wells & Nieuwenhuis' (2012) discussion of this 'institutional isomorphism' has already been noted. New vehicle technologies may be disruptive in nature or may require different manufacturing processes and conceptions of motor vehicle manufacture and, in turn, the introduction of new vehicle technologies may require new conceptions of the automotive industry business model. Given the degree to which the business model is embedded in the socio-technical regime, a transition may not be completely painless. *"This business model is at the heart of the current car industry, much of the world has readily adopted it and many more are eagerly waiting to adopt it."* (Nieuwenhuis P. , 2012, p. 18)

## 3.2 Genesis of the Automotive Industry Business Model

This section explains the genesis of the Automotive Industry's business model through three main developments. This formed the template for the automotive regime during the period that American practices shaped and dominated the car industry. This is contrasted against later developments in the Japanese motor industry, which can be seen as shaping the business model globally.

1. Ford's moving assembly line formed the pattern for the organisation of labour in the value-creation dimensions of the automotive industry business model. This introduced standardisation of components (Where interchangeable components made to tolerance replaced 'hand fitted' components). Through standardising processes (replacing 'craft' manufacture of parts, with repetitive machine processes and specialised tools) less skilled labour could be used for assembly tasks. However, there were several shortcomings to Ford's business model. The "value capture" side of the business model was underdeveloped allowing Sloan to exploit weaknesses in Ford's lack of segmentation. Furthermore, processes for bodywork manufacture were slow and limited the efficiency of the overall operation.
2. Budd's key process innovation was the development of pressed steel bodywork tooling and processes. Arc-welding was used to join the pressed steel components together. This changed the nature of the key activities used for manufacturing automotive bodies, by industrialising the processes and removing "craft processes" from the line. The cycle times with which pressed steel could be produced removed the "bottleneck" of slow body production at Ford's and paved the way for monocoque vehicle design.
3. Sloan's innovations at General Motors transformed the 'value capture' side of the Automotive Industry business model. Sloan introduced 'Customer Segmentation' producing a range of vehicles to suit a range of customers. This created variety and novelty and enabled the 'customer relationship' to be tailored to the profitability of the customer through creation of different brand houses. Sloan also created an additional revenue stream through vehicle finance.

### 3.2.1 Ford – Efficient Production with the Moving Assembly Line



**Business Model Canvas 1 - Early Ford Business Model**

Many attempts to account for the development of the automotive business model start with Henry Ford. De Grazia, (2005, p. 4) offers a précis of Fordism as *"the eponymous manufacturing system designed to spew out standardized, low-cost goods and afford its workers decent enough wages to buy them."* The success of the early Ford Motor Company was largely based around the introduction of the Model T. Small and durable, the Model T was mass produced thus lowering the unit cost to manufacture and allowing the Ford Motor Company to price it at a point that made it attractive to the average consumer. Through this (at the time) revolutionary business model, Ford brought automobility within the reach of the average consumer and, in the process, revolutionised an industry and drove his company to the point at which one vehicle, the Model T, constituted 60% of the United States Automobile output (Rae 1969, p. 45). Tolliday & Zeitlin (1987, pp. 1-2) consider Fordism as *"a model of economic expansion and technological progress based on the mass production: the manufacture of standardized products in huge volumes using special purpose machinery and unskilled labour"*

Fordist production systems can be distinguished over their predecessors by a number of features:

- The concept of the assembly line and tools that were designed for purpose so that complex tasks could be simplified. (Burrows, Gilbert, & Pollert, 1992, pp. 13-17)
- The production line significantly speeded up the production process by a factor of eight. However, the process was still constrained by bodywork and paint technologies.
- The removal of skilled processes combined with enhanced remuneration for the worker.
- Variation was eliminated from the product through standardisation and rationalisation. Between the years of 1914 and 1925, Model T's were only manufactured in black in order to speed the assembly line, as black paint was the fastest drying formulation. This anecdote perfectly illustrates the tenets of Fordism; standardisation in pursuit of efficiency and lower costs. This is epitomised by the apocryphal Henry Ford misquote taken from his autobiography (Ford, 1922)

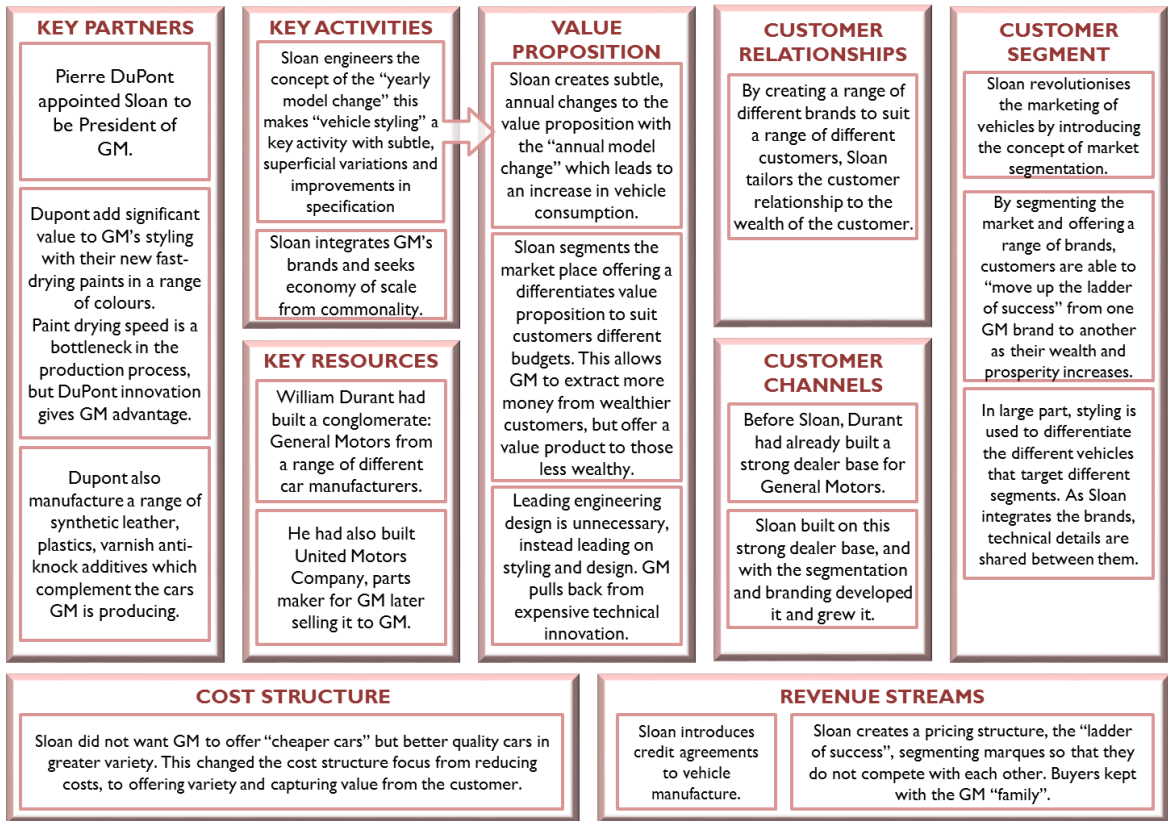
***“Therefore in 1909 I announced one morning, without any previous warning, that in the future we were going to build only one model, that the model was going to be "Model T," and that the chassis would be exactly the same for all cars, and I remarked: Any customer can have a car painted any color that he wants so long as it is black.”***

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**(Ford, 1922)**

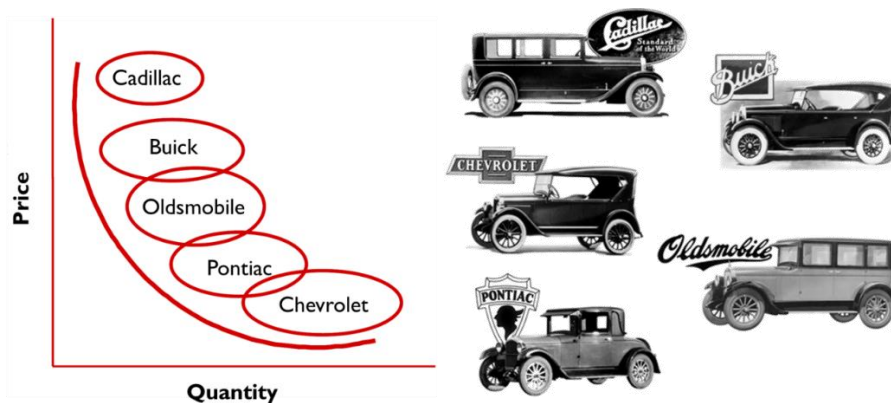
In the UK, the construction of Ford's Trafford Park factory in 1911 on what was to be the first planned industrial estate in the world (Nicholls, 1996, p. xiii) was to mark the beginning of Fordism in the UK car industry. Initially Model T vehicles were assembled on the line until production transferred to Ford's new Dagenham plant in 1931 (Nicholls, 1996, pp. 63-65).

### 3.2.2 General Motors - Encouraging Consumption



**Business Model Canvas 2 - Sloan's General Motors business model.**

If Ford introduced the elements of the automotive business model that would go on to define the blueprint for the 'Production' side of the business model, then it was Alfred P. Sloan who would go on to define many enduring elements of the 'Consumption' side of the automotive business model with the concepts of market segmentation and creating a culture of consumption through styling engineered obsolescence and the annual model change.



**Figure 37 - Sloan & Market Segmentation of General Motors**  
 Diagram Left Redrawn from (Nobrega, 2009), Photo credit right, GM, taken from (Skillings, 2009)

Sloan was put in charge of General Motors by Dupont. Dupont had allied industries which formed a key partnership for General Motors that was leveraged for competitive advantage. The main reason that Ford cars had come to be offered only in black was that it was the fastest drying paint colour. At the time, coloured enamels were available, but they were slow to dry which was a bottleneck on the key activities. Dupont developed fast drying coloured paints, which allowed a range of colours to be offered at the same time as ensuring that the key activities were swiftly undertaken. This additional colour choice was one facet of Sloan's strategy to offer more choice to customers.

Another big departure from Ford's model was the segmentation of customers. Sloan called this the "ladder of success", differentiating more modest vehicles from high-end vehicles. Some of the differentiation between vehicles was superficial – tweaks to styling and design to give them impression of a higher end vehicle. In truth, much of the mechanical underpinnings of GM vehicles were old technology. It is alleged that there was a mantra amongst GM engineers "*Whatever you do, don't let GM do it first.*": technical innovation was seen as being expensive, unpredictable and unwanted whereas styling and design could be updated very cheaply.

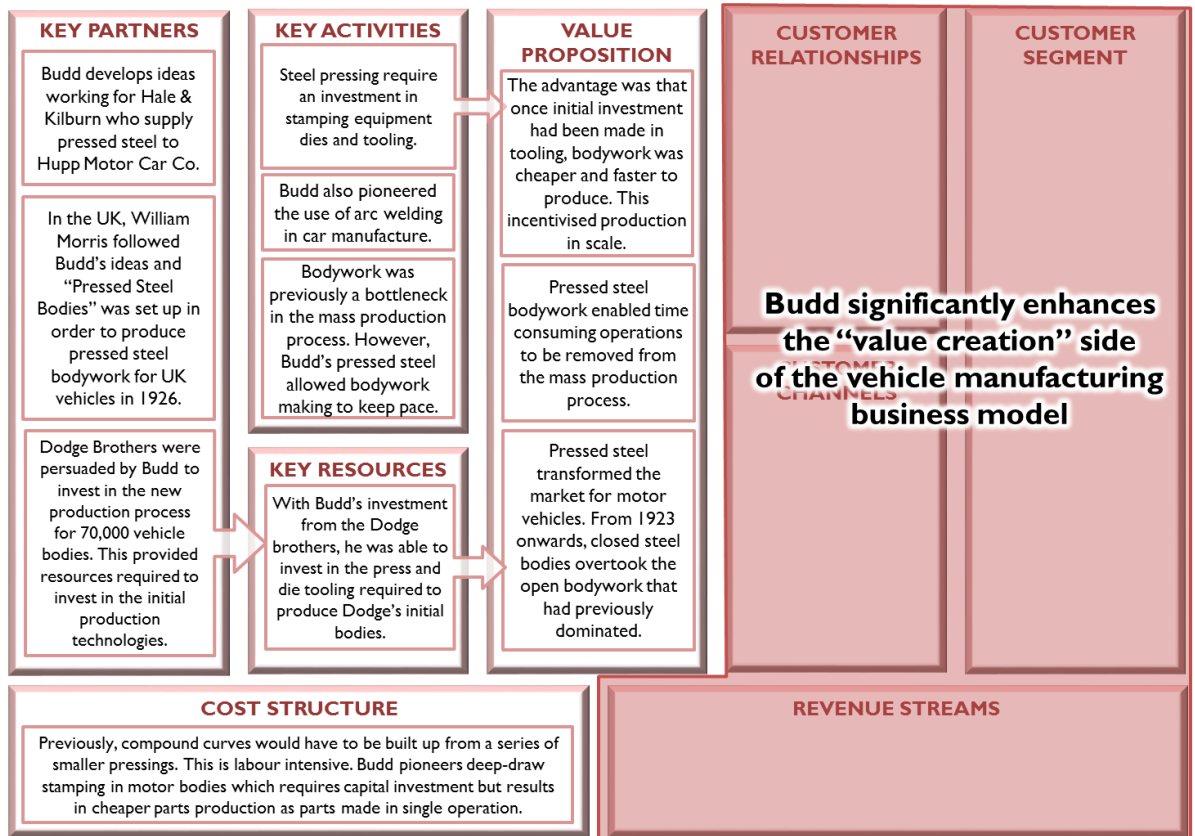
This led to the concept of yearly revisions of design, minor tweaks and alterations, in order to create demand for vehicles. The 'yearly model change' (Giucci, 2012, pp. 35, 146) posed a significant challenge for Henry Ford's ideal of practicality, as he eschewed '*style and comfort*' as '*waste*'. (Giucci, 2012, p. 35).

Whereas Ford's business model was primarily geared around cost reduction through concentrating on basic utility, General Motors business model was focused around offering customers variety and a quality of vehicle to suit their budget, ultimately extracting more money from individual customers.

Another key addition was the value stream of "credit" for consumers. Ford had refused to offer credit initially on his vehicles. However, GM saw an opportunity to make vehicles that were hitherto out of the reach of customers within their grasp, whilst simultaneously creating additional revenue streams.

GM's business model innovation were very disruptive, Ford's market share quickly fell.

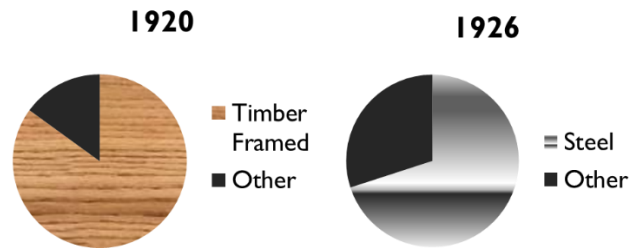
### 3.2.3 Budd – Pressed Steel Bodywork for Speed & Efficiency



**Business Model Canvas 3 – Budd's Pressed Steel Bodywork**

Niewenhuis & Wells (2007) argue that many overstate the role of Henry Ford when constructing a narrative of the automotive industry's evolution. Ford is commonly hailed as the "father of mass-production", however whilst Ford used mass production for the production of key components and sub-assemblies, the processes that he used for vehicle body assembly were slow and cumbersome.

They assert that the role of Edward G. Budd is underplayed. Budd developed the processes of working with pressed steel, the bodywork of most mainstream vehicles. Before Budd, vehicle bodies were time consuming to make. Often vehicles employed wood for a significant portion of their bodywork. Paints at the time were slow drying, and attempts to accelerate the drying times of the paint with heating was problematic as the wood was a fire risk (Nieuwenhuis & Wells, 2007). Budd's invention became even more central, when Budd and Citroen designed the first monocoque body in 1934. The steel pressings became not only the external shell, but also the structural support for all vehicle components, dispensing with the need for a chassis. (Niewenhuis & Wells, 2007). Overleaf, Figure 38 illustrates the disruptive effect of Budd's innovation on vehicle manufacture.



**Figure 38 – Budd’s Transformation of the Vehicle Industry Nieuwenhuis & Wells, (2003)**

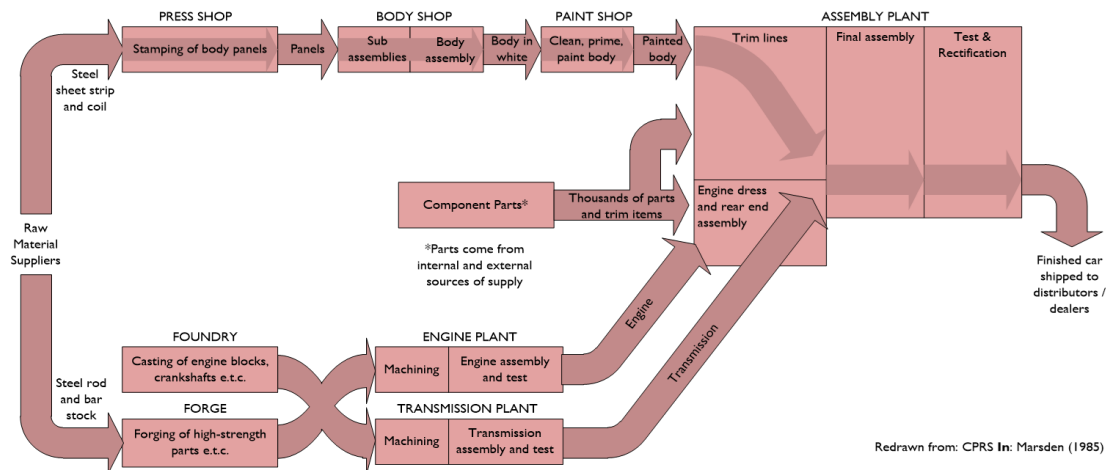
Theobald (2004) notes that the price of pressed steel bodies at the time was comparable to “composite” bodies that were made from a combination of wood, steel and aluminum. The massive labour saving was in the finishing of the bodywork. Whereas composite bodies could take weeks of finishing, the all steel body could be finished and painted in a day. There were no flammable components allowed, so the steel bodies could be “baked” so the paint would dry quickly.

Theobald (2004) also notes that it initially took time to perfect the process of pressed steel manufacture. Producing adequate stamped panels was the initial challenge; however, the secondary challenge which required attention was how to join the panels together. Welding caused heat which had the potential to distort the panels. Arc welding was eventually perfected which, with the use of jigs, could join the panels together satisfactorily without distortion. The same principles are used in modern vehicle assembly and the process retains many of its features. Automation has reduced the manual labour content significantly with robots being used to both handle stamping operations, vehicle assembly and welding operations but the processes of press steel and arc welding still underpin this business model.

In Figure 39, overleaf a now dated view of car assembly can be seen. The modern factory may have many component suppliers and module manufacturers working within the factory as self-contained units and carrying out individual tasks in isolation, but it has evolved from the simple model of production below. Furthermore, there may not be the same level of vertical integration, with all operations such as foundry and forge occurring on the same premises. However, there is much in the



simple model of manufacturing below that can still be observed in the mainstream car industry. Crucial to the business model below is the innovations introduced by Budd of pressed steel bodywork and the ICE.

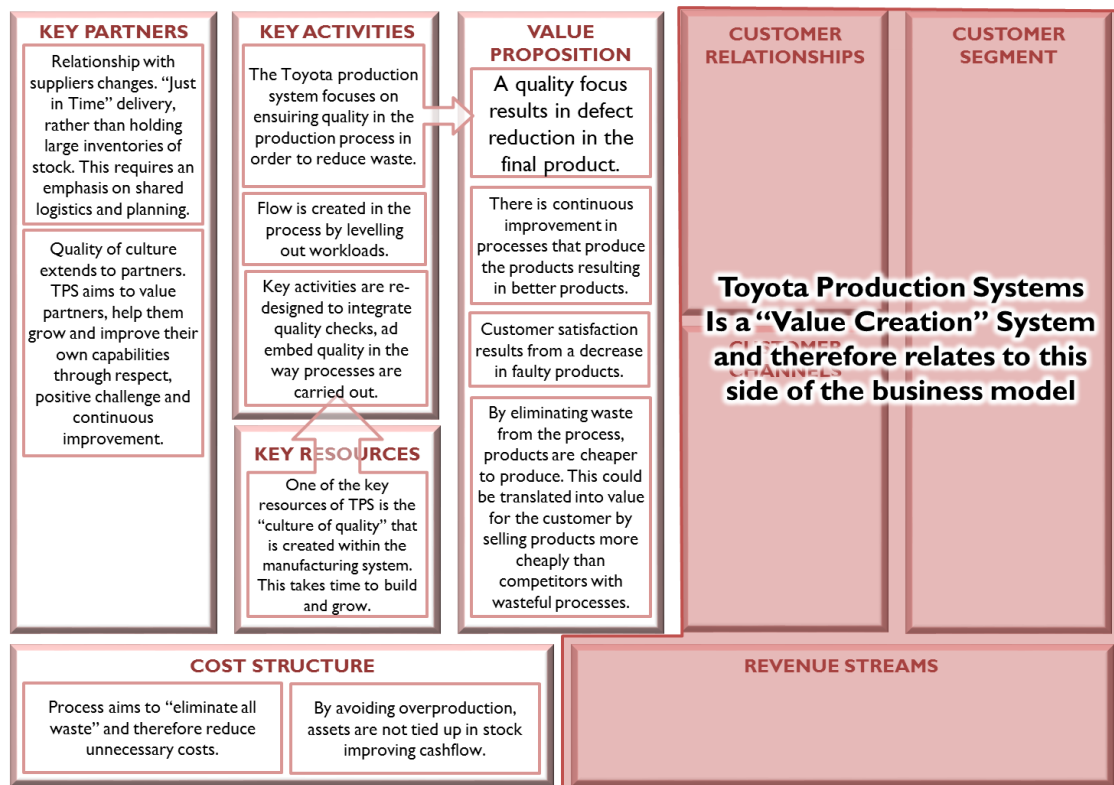


**Figure 39 – Configuration of Vehicle Manufacture Activities based around Pressed Steel & Internal Combustion Engines**

In the UK automotive industry, Budd had formed an alliance with William Morris. This joint venture was to culminate in the formation of “Pressed Steel Bodies”, who produced Press Steel for Morris Cars, and later were merged into BMC. Pressed Steel Bodies (1937) had acquired Budd’s patents for use in the UK marketplace. For some time, they supplied press steelwork for a range of UK vehicle manufacturers.

Thinking about how this model will evolve for ULEV manufacture; for many mass-produced ULEVs being introduced to the marketplace, there is still a reliance on pressed steel bodywork. This key activity in turn defines much of the structure and configuration of the industry’s business mode. That said, the core processes relating to drivetrain manufacture are changing. The electrification of vehicle drivetrains necessitates change in the processes for drivetrain manufacture. Value creation is distributed in a different way; the creation of fuel cells and battery technology will become significant focuses of value creation. However, the industry’s familiar processes for creating bodywork in many cases remain the same. Pressed steel may be cheap to produce and familiar to the industry but it is also heavy compared to the alternatives. Later in this section, the case of BMWi is examined. BMW have invested heavily in production equipment from carbon fibre, which has hitherto been seen as too expensive for volume vehicle manufacture.

### 3.3 Modern, Toyota Production System (TPS)



**Business Model Canvas 4 - Toyota Production System Business Model**

Toyota pioneered many new techniques, which came to be known as the "Toyota Production System". This transformed the value-creation dimension of the Japanese car industry by removing waste from the system. This was done through the design of products and processes to remove overburden (muri) and inconsistency (mura) which in turn lead to the reduction of waste (muda).

As Japanese cars gained market share, the rest of the automotive industry began to realise what a powerful series of tools had been created to improve production processes. Wood (1993, p. 535) views the Toyota Production System as an "evolution of Fordism, within Fordism rather than a transformation of it, i.e. neo Fordism not Post Fordism". Wood (1993) highlights that the TPS challenges the association of mass-production with inflexibility, whilst still retaining the features of process: work study, assembly lines, mass production and marketing that are at the heart of Fordism.

The results of this disruptive success are borne out in the transformation of the car industry. Toyota is currently the world's largest automaker, currently employing over 300,000 people globally. Furthermore, Toyota is recognised as being consistently more productive than its competitors.

### 3.3.1 The Toyota Way

The philosophy of the "Toyota Motor Company" is one that differentiates itself from many western car manufacturers and is commonly called "The Toyota Way". The Toyota Way, consisting of fourteen principles, believes that long-term thinking, even when short term gain is sacrificed, is a key principle for the company. There is also a belief that organisational value can be added to the company by developing its people. It also states that root problems within the company should be dealt with head-on as a vital part of organisational learning providing problem-solving approaches to resolve difficulties. There is a great deal of scholarship and interest in Toyota's methods (DeLorenzo, 2007; Liker & Hoseus, 2007; Magee, 2008; Morgan J. M., 2006; Ohno, 1988; Osono, 2008; Spear & Bowen, 1999). It is a clear study of how Toyota has shaped management thinking greatly.

### 3.3.2 The Toyota Production System

The Toyota Production System is integral to the Toyota Way and Toyota's car production business model; many elements have been adopted internationally by other car makers.

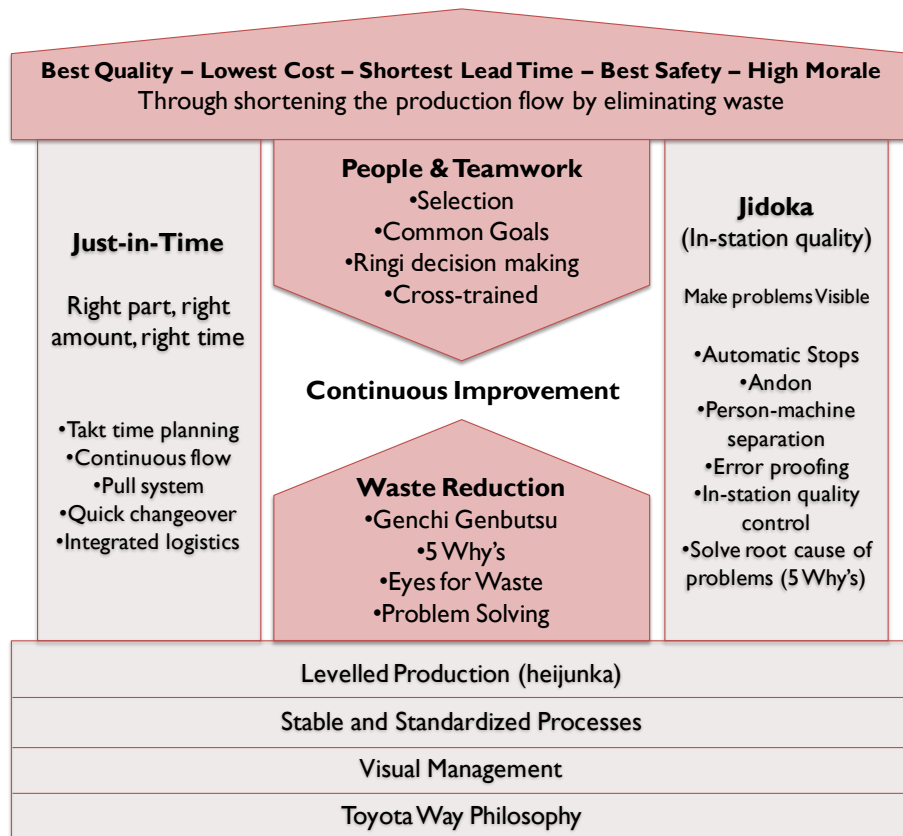
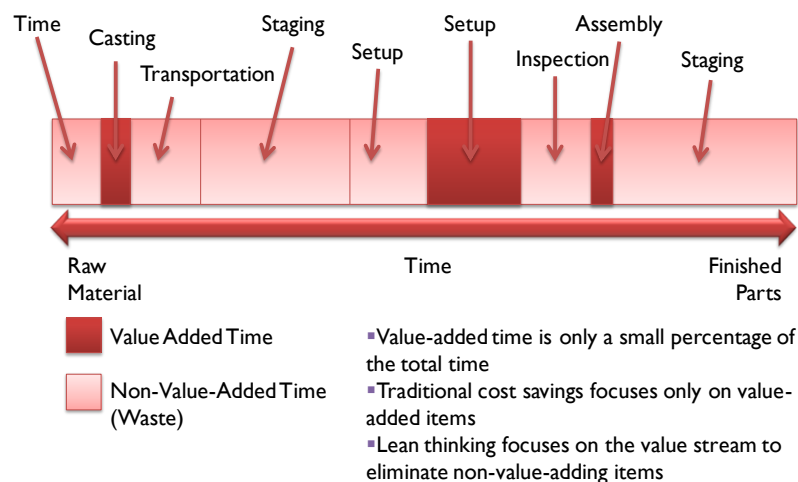


Figure 40 - Visual Representation of the Toyota Production System (Liker, 2004, p.33)

The Toyota Production System has allowed Toyota to reduce lead-times on products, reduce prices and all whilst improving quality. One of key principles of the TPS is to smooth production to ensure that there is flow in processes; to draw an analogy with the popular fable, TPS aims to be like the "tortoise" not the "hare". By designing out inconsistencies in products and engineering processes to produce the minimum possible defects, the production process can flow smoothly and waste can be eliminated. The system is also designed to even out stress as a result of overburdening employees or equipment. There are three kinds of waste that the TPS aims to eliminate:

1. Waste as a result of over-production
2. Wasted motion (of people or machines)
3. Waste time as a result of waiting

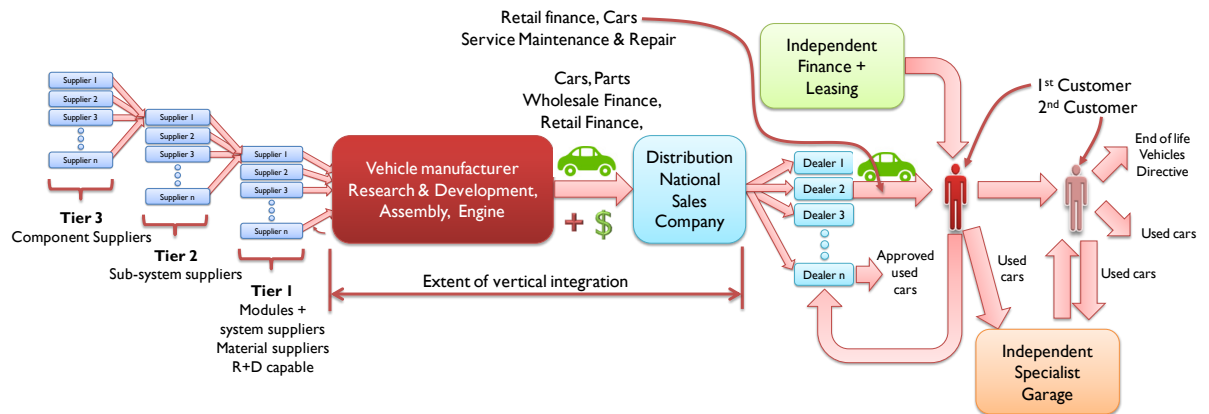
Whereas many previous approaches to improving efficiency focused on the times in vehicle assembly where value was being added, the Toyota Production System examined carefully all the periods of non-value added time to see where efficiencies could be made.



**Figure 41 - Reducing Waste By Eliminating Non Value-Adding Items: From (Liker, 2004, p.30)**

The mantra of lean manufacturing is to achieve more value with less work. Lean manufacturing techniques aim to reduce "muda" or waste, which in turn improves quality, production time and cost, by analysing the "flow" of work through a manufacturing system. This analysis of flow encompasses not only actions within the firm, but also outside of it. Systems are also designed to reduce defects through making processes intuitive. 'Poka yoke', which means 'mistake proofing' entails designing components so that they can only fit together in one orientation; design eliminates defect potential.

The culture of the Toyota Production System did not only extend to operatives working in Toyota's plants, but the culture also extended into those firms supplying Toyota. Part of the culture of Toyota was to have respect for and help to grow and nurture the supplier base. Toyota recognised that helping suppliers to learn quality processes would in turn benefit Toyota in the long run.



**Figure 42 - The Toyota Production System an extended view: as advanced by (Wells P. E., 2010b, p. 116)**

Another significant change to the relationship with suppliers was the change to logistics and stock control. “Just-in-time” is a strategy that has been employed by Toyota to improve its inventory management, reducing the carrying costs of stocking large numbers of components and improving quality, efficiency and return on investment. The philosophy of JIT is that stocked inventory is waste. In traditional manufacturing, large stores of components are kept at each stage of the process to ensure business continuity and providing a ‘buffer’ to match the input and output rates of different processes. Just-in-time replaces the storage of manufactured items that is waiting to reach the next stage of the manufacturing process with very efficient logistics, control and communication.

Elements of Japanese style manufacturing practice therefore began to permeate into UK industry,

	First Introduced	Median Date
<b>Statistical Process Control</b>	1948-52	1983
<b>Flexible Working</b>	1958-62	1981
<b>Work Groups / Teams</b>	1958-62	1983
<b>Quality Circles</b>	1973-77	1983
<b>Just-in-time Production</b>	1973-77	1986

**Table 13 - Introduction of Japanese-style Work Organisation in the UK**  
 Reproduced from (Oliver & Wilkinson, 1988) in (Fujimoto & Tidd, The UK and Japanese Automobile Industries: Adoption and Adaptation of Fordism, 1993)

### 3.4 Recent Evolution of the Automotive Industry Business Model

In order to survive and adapt, there are a number of emergent trends that can be witnessed amongst large scale VMs. The large companies that form the bulk of the industry are sourcing components from a variety of international markets, which means that their business models are in turn being shaped by the demands of a range of global suppliers. There are also external contextual issues that put pressure on the business model. Walters & Newton present the following diagram to explain their view of the international automotive industry business model.

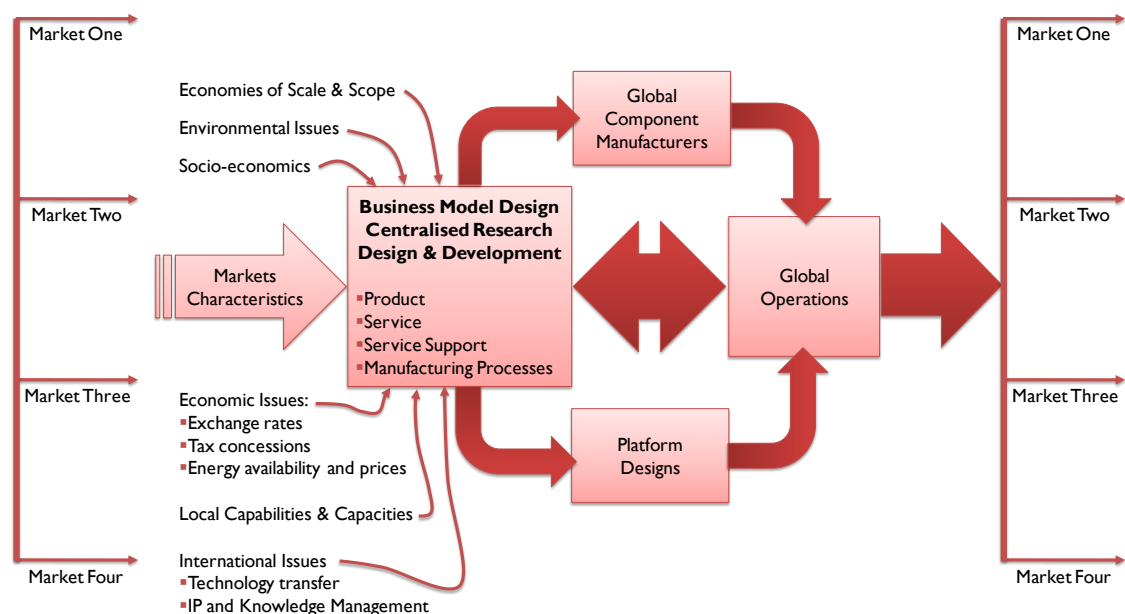


Figure 43 - Global business model of the automotive industry operations (Walters & Newton, 2010, p. 6)

This is one interpretation and captures a variety of pressures and influencing factors, such as exchange rates and tax concessions. In this thesis, Osterwalder & Pigneur's (2006) business model canvas has been used to interpret firms' business models. Therefore, in the next sections, the classifications of the business model ontology have been adopted in order to briefly outline key changes. These will again be revisited in the conclusions to see how the introduction of ULEVs is further shaping the industry.

As mentioned, Figure 43 above captures factors external to the business model. In the UK context, these external contextual factors are examined in Chapter 5 (p.210)

### 3.4.1 Key Partners

There have been a number of significant changes in the relationships between VMs and their suppliers. There is an ongoing trend of aggregation of OEM's and suppliers, which concentrates production into a smaller group of suppliers with whom closer relationships are formed (Wengel, Warnke, & Lindbom, 2003, p. 5). This also simplifies the number of relationships that VM's have to manage. This has been accompanied by changes, with component suppliers capturing greater value through making ever larger modules and sub-assemblies. This allows for specialisation, this specialisation leads to economies in knowledge production, and knowledge of sub-assembly technologies may be shared across vehicle marques. McAlinden, Smith & Swiecki (1999) suggest that there is an emerging tier of "super system suppliers". They cite Day (1999) who describes the tier "0.5" of advanced suppliers who offer additional value added in terms of their ability to integrate components and design modules.

The competency base and balance of skills between OEM's and suppliers is shifting; "*manufacturers are re-evaluating their supply chain activities and are reconfiguring the value pyramid in innovative ways.*" (Nitschke, 2005; Collins, Bechler, & Pires, 1997; Pavlínek & Janák, 2007). Increasingly, top tier suppliers are integrated into the process of vehicle assembly, running operations in a section of a vehicle manufacturing process within the VM's factory.

In the long term, there has also been a narrative of the internationalisation of manufacturing (Wengel, Warnke, & Lindbom, 2003, p. 5), transferring manufacturing to countries where labour costs are lower and forming joint and local ventures and subsidiaries in emerging economies [particularly the BRIC countries] (Horn, Forsans, & Cross, 2010; Lee & Lee, 2007). This has not been a universal success. There have been several high-profile product recalls as a result of poor quality and inferior goods in markets where there is not the same culture of quality (Foy, 2014; Dan, 2014; Navarro & Autry, 2011, p.42-43). There have also be challenges with te 'response time' of offshore manufacture, resulting from long supply chains (Ellram, Tate & Petersen, 2013: 14) As a result, there is an emergent narrative of "reshoring" i.e. reversing the trend of offshoring by re-establishing relationships with indigenous component suppliers. Groom (2013) reports that one in six manufacturing businesses is reshoring business from lower cost countries, with the flow of 'reshored' manufacture now exceeding manufacture that is being 'offshored'.

Furthermore, as will be explored later in this thesis, ULEVs require manufactures to engage with new key partners, some of whom may be outside of the traditional automotive industry.

### 3.4.2 Key Activities

The process of car manufacture in the mainstream industry relies on a combination of pressed steel bodywork and the internal combustion engine; this much has remained relatively constant in the automotive business model. However, there have been a number of changes around the organisation of key activities and how these are carried out within the industry.

Platform strategies are a reconfiguration of how a firm carries out its engineering functions. There is a focus on creating a variety of vehicle designs from a common engineering base. These platforms extend across marques and manufacturers from competing car makers may often collaborate on a platform if shared costs enable them. Models that appear different in style share common engineering underpinnings reducing development costs. These platforms may encompass not only the vehicle's mechanical design, but increasingly the design of sophisticated electronic control systems which provide value added functions, and also advanced telematics, vehicle navigation and entertainment. Several car makers have announced plans to reduce the number of platforms vehicles are built on, instead opting for more flexible platforms to reduce development costs (Ogana 2014; Ogana 2014)

There is also pressure on volume manufacturers to defend against the erosion of their market by niche products. As a result, flexible manufacturing methods and platform strategies are allowing volume manufacturers to produce "niche" vehicles that are based on common engineering underpinnings. This requires flexibility of manufacture. Historically, some short-production vehicles have been outsourced to contract manufacturers; however, increasingly flexible manufacturing methods are allowing more to be done in house.



### 3.4.3 Key Resources

As outlined in Key Partners, additional responsibilities for research and development are being devolved to Tier I (or Tier 0.5) suppliers who are increasingly designing whole modules rather than individual components. This represents a shift in the intellectual resource distribution within the car industry. More and more, rather than a company developing knowledge in house, it is being sourced from outside the firm.

Furthermore, increased collaboration in the form of platforms and joint ventures marks a shift in the distribution of key resources, as manufacturers work to share the cost of development and spread the risks associated with new model creation.

An increase in the cost of raw materials as a result of global demand has led to an overall downsizing of equivalent new models. This is down to two main factors: manufacturers seeking to reduce costs and consumers seeking economy (Independent, 2009).

The physical infrastructure of manufacturing has grown too large for the current demand. There is great overcapacity in the industry and, in this context, physical resources quickly turn into liabilities. What once would have been considered an asset in the car industry is fast turning into a burden. Bailey (2013a) notes that vehicle manufacturers exacerbated the problem by building further excess capacity in Eastern Europe, and consider that there is 25% overcapacity, potentially more. Bailey (2013a) cites Alix Partners as saying that 60% of European car plants are operating at 75% capacity or less, and it is at this figure that they achieve break-even.

The distribution of ownership of firms is also changing significantly too. Nations with fast developing economies have been keen to acquire Western brands, as Godement, Parello-Plesner & Richard (2011) observe. EU Business (2012) notes the Chinese car maker Geely's acquisition of Volvo. Chery, another Chinese carmaker, has bought a car plant from Fiat in Sicily (Ciferri, 2011) and Dongfeng have acquired an interest in PSA (Hotten, 2013).

### 3.4.4 Value Proposition

Globally, there has been a move to downsizing vehicles as a result of increasing resource prices (as noted in the previous section). This also reflects changes in the marketplace with consumers opting for smaller vehicles. Ingram (2012) reports the results of the U.S. Automotive Performance, Execution and Layout (APEAL) study which shows a general trend of customers downsizing.

There has been a great deal of pressure on the mid-market as a result of overcapacity (Stones, 2004); consumers have either migrated downmarket to increasingly high quality value offerings, or upmarket to premium brands that are increasingly offering compact 'starter' vehicles in their marques (Stones, 2004). As noted in key activities, volume manufacturers are responding to the demand of customer segments for increasing variety and customisation with specialist models based on platforms used for volume produced vehicles. These vehicles are low-volume for the mainstream vehicle industry but make use of the economies of scale from platform strategies.

Also, with flexible manufacturing comes the potential for mass customisation of vehicles. This requires a combination of both a customer interface that allows vehicles to be customised intuitively, but also the VMs key activities configured in such a way that vehicles can be made quickly "on demand" to customers specifications (Helo, Xu, Kyllönen, & Jiao, 2010)

Ingram (2012) notes that 'economy' has slowly been rising in the concerns of consumers prompted in part by the global recession. The growing cost of emissions controls for diesel vehicles has led the industry to re-evaluate the petrol engine. Whilst there has been a long term trend of dieselisation in the UK market, there is now growth in small, innovative and efficient petrol engines (Edelstein, 2013).

ULEVs remain a niche market, and in many ways they are an entirely different value proposition from the mainstream. There is a great "diversity" of solutions on the market (Harper & Wells, 2012). Will this diversity endure or will a clear value proposition emerge that is sufficiently compelling to dominate over others? Will manufacturers produce ULEVs as variants of their mainstream vehicles, or will they produce bespoke platforms? Some of these questions will be explored in the empirical work.

### 3.4.5 Customer Relationships & Customer Channels

In the volume car industry, dealership networks still form the backbone of the infrastructure that underpins the customer channels and manages the customer relationship; here, these two business model elements are considered as part of the same narrative.

One of the most significant challenges in recent years is the change from single to multi-brand dealerships. For approximately twenty years, “block exemption regulations” have governed the nature of dealership networks in the EU. In 2002, a change of policy led to dealers being released from the constraints of selling a single marque of vehicles to being able to deal in multiple marques (Klein, Greiner, Genßler Kuhn & Born 2007, p.760). Within this change was a ten-year “safe harbour” that protected dealers from the full glare of EU competition law (Ciferri & McVeigh, 2011). Gibbs (2012) notes how many European dealerships have chosen to reshape their European dealer networks as a result of this change in legislation by removing underperforming dealerships.

Berk (2013) suggests that the franchise dealership system is a “*business model that began as a way for automakers to spread their geographic reach quickly and with minimal corporate investment*”. However, is this model still fit for the 21<sup>st</sup> century?

In many other spheres of business, the internet and Web 2.0 technologies have radically transformed the way that products and services are distributed. Frost & Sullivan (2014) note the global growth in “digital lifestyle stores” being opened by VMs. These offer a qualitatively different experience from the traditional car dealership. They change the focus from a “retail” focus to a “brand experience” focus (Frost & Sullivan, 2014). They are characterised by being built in busy city centres and by a lack of physical inventory in store.

Frost & Sullivan (2014) predict that upwards of 20% conventional dealership space will give way to the new technologies of “*gamification, augmented reality, and 3D technology*”. Frost & Sullivan note a divergence between the EU and the US; in the US model, digital technologies augment the existing customer channels of the dealership network, enhancing them and providing an additional tool for

sales staff. By contrast, in the EU, Frost & Sullivan note a more radical approach where Audi, JLR and Nissan have all launched “diverse digital showroom concepts”.

Frost & Sullivan consider that the following range of technologies will all form a component of the future customer relationship: “high-level car configurators, 3-D displays, augmented reality, virtual test drives, holographic simulations, remote car diagnostics, online service/repair booking, and assisted repair.”

<b>Conventional Dealership</b>	<i>A car-retailing outlet that follows the traditional model of showcasing physical inventory, with the majority of its sales activity happening offline.</i>
<b>Digital Showroom</b>	<i>Digital showrooms feature digital tools specifically aimed at enhancing both the retail and brand experience. They have limited on-floor physical inventory and may or may not be involved in actual sales transactions.</i>
<b>Lifestyle Store</b>	<i>Lifestyle stores offer a strong automotive brand experience through lifestyle-related concepts of art, fashion, music, design, food, and technology. The store is not centred around the actual sales transaction of a car.</i>
<b>Pop-up Store</b>	<i>Pop-up stores are temporary stores with 3D visuals and QR codes at high-traffic locations that are used, for example, to draw the public's attention to a new car model.</i>

**Table 14 - Future Car Retailing Formats: Constructed from Frost & Sullivan (2014)**

Carroll (2014) notes that the technology that is within cars and drives them is changing rapidly. It is a challenge for manufacturers to ensure that their sales workforce remains up to date with developments. Furthermore, it is a challenge for car companies to maintain the customer relationship with their customers when in-car entertainment technology sold today may be out of date in two years. This is especially an issue considering the connectivity of cars with fast evolving mobile devices.

Carroll (2014) picks up on another point about fast moving digital technologies. These are the portals through which customers will increasingly form impressions about brands. He notes, by way of comparison, the User Interfaces of Smart TVs. With mobile devices and the internet setting such a high level of expectation for user interaction and user experience, firms in sectors that have to adapt to this new reality are slow to respond. The result is “Smart TVs” with “dumb user interfaces”. Carroll (2014) applies the same logic to vehicle manufacturers, noting that experiences of interacting with digital equipment in vehicles is disappointing compared with up to date mobile devices.

Digital technologies will undoubtedly shape the future Customer Channels used to buy and sell vehicles and the nature of the customer relationships those channels mediate.

### 3.4.6 Customer Segments

There has been a tectonic shift in the car industry, with developed Western markets stagnating, whilst developing markets such as the BRIC countries are rapidly increasing their demand for vehicles as their indigenous wealth grows.

In 2009, China overtook the US as the largest car market by volume (Barris, 2013). China and India are expected to account for around 40% of vehicle sales growth in the next 5-7 years (Barris, 2013). That said, there has also been spectacular growth in the brands available to consumers in these countries, as indigenous ventures set up and try to capture part of the market. There are now 379 brands for sale in China up from 64 only 10 years ago (Barris, 2013).

Within the UK marketplace, there has been a trend for vehicle manufacturers to 'push upmarket' the image of UK built cars. Holloway (2013) has observed that this trend will be a pre-requisite for European manufacturers to survive as the value segment from low-cost countries encroaches on their value proposition. The luxury vehicles market has been growing, as those with conspicuous wealth seek to differentiate themselves. Alongside this, there is a trend of growth in the value vehicle market. Many VMs have launched or re-launched value segment brands. Renault has revived the Dacia brand, the same with Nissan and the Datsun brand; both to serve in value markets, whilst preserving the brand prestige of Nissan and Renault respectively.

However, the middle-ground of the market has stagnated by comparison. It is the study of much contemporary academic study to look at the phenomenon of "the squeezed middle" (Parker, 2013); the idea that for the wealthy, the modest drop in economic output has been of little consequence for those that have cash reserves to cushion them, whereas for the less well-off in developed countries, there are some mechanisms provided by the welfare state which serve to provide a baseline standard of living. Those that have experienced the largest change in prosperity are those in the middle ground. Hacker (2013, p. 143) discusses the stagnation of median wages.

### **3.4.7 Cost Structure**

The global motor industry faces a number of major challenges. Nieuwenhuis & Wells (1997) address the 'chronic lack of profitability' in the industry. It is important to note that this is a long term trend that pre-dates the more recent '2008-2010' crisis of the automotive industry. Wells (2001, p. 6) notes that even widespread reconfigurations have been unable to address this problem.

Traditional approaches to improving the cost structure of mass production, including reducing unit costs through increasing annual production (Rhys 1977, p. 315) only holds true when there is demand for the increased production. Another alternative to this is to increase model life (Rhys 1977, p. 315). However, this approach is gaining in difficulty given the demand from customers for new styles. Increasingly platform strategies and joint ventures are used to bring down model development costs.

Walters & Newton (2010) analyse how the car industry is emerging from the recession and have advanced how they feel the business model of the car industry as it changes with reference to costs and revenues. They note how large manufacturers are helping to use their massive buying power as leverage to help suppliers secure lower cost raw materials, who can then in turn pass cost savings onto vehicle manufacturers.

### **3.4.8 Revenue Streams**

Vehicle manufacturers still primarily make their money through "shifting metal", in other words, revenue is linked to the volume of cars that is sold. It has already been noted how some have perceived this attitude as a barrier to business model innovation (Maxton & Wormald, 2004).

That said, there has been engagement from manufacturers with alternative business models. Peugeot with its 'Mu' offering perhaps hints at a future transition away from a Revenue stream primarily based around the sale of vehicles and more towards a mobility service offer.

Similarly, BMW have acquired stakes in a range of companies offering "mobility services". Their level of investment in the creation of the BMWi brand is a clear indication that they are pursuing a more diverse range of revenue streams going forward.

### 3.5 Business Models for Smaller Firms

This chapter thus far has explored how the business model of the main market - the regime - has evolved and changed over time. However, these are not the only companies that are producing vehicles in the UK marketplace. There are also a range of smaller firms; indeed, the abundance of small firms is one of the differentiating features of the UK culture of automobility.

Rhys (1977, p. 242) proposes one definition of the 'smaller firm'; "*In any market for any good where economies of scale exist in its production, firms smaller than the optimum could, if no non-scale problems exist, be at a cost and, with competition, a profit disadvantage.*". Rhys (1977) highlights that due to the lack of economies of scale, smaller firms have to be "*able to charge a premium price to offset higher unit costs*". In echoes of the previous section, Rhys (1977, p. 252) notes that, in the European car industry of the day, the most profitable element of the car industry were not the mass producers but the medium-sized firms who were able to command a premium price for perceived quality. The mass producers "*operated in a more homogenous, price conscious market*", and by contrast, the greater degree of product differentiation employed by medium sized quality producers could charge their **CUSTOMER SEGMENTS** what they would bear.

There is already discussion in the literature about the degree to which the introduction of ULEVs will require new production technologies. There is a certain amount of prescience in Rhys' comment (1977, p. 254): "*It could be that the development of a truly viable alternative to the internal combustion engined car, say an electric or steam car, may require a production technology which substantially reduces the optimum size of car producers*". More contemporary sources have suggested that changing the scale of the automotive industry's business model may be the key to unlocking more sustainable processes through 'micro factory retailing' (Wells & Nieuwenhuis, 1999).

In the case studies, smaller firms are examined, as they offer an interesting counterpoint to the mainstream industry and a potential source of new innovation. These following sections explore some of the business models employed by smaller firms.

### 3.5.1 Contract manufacturers

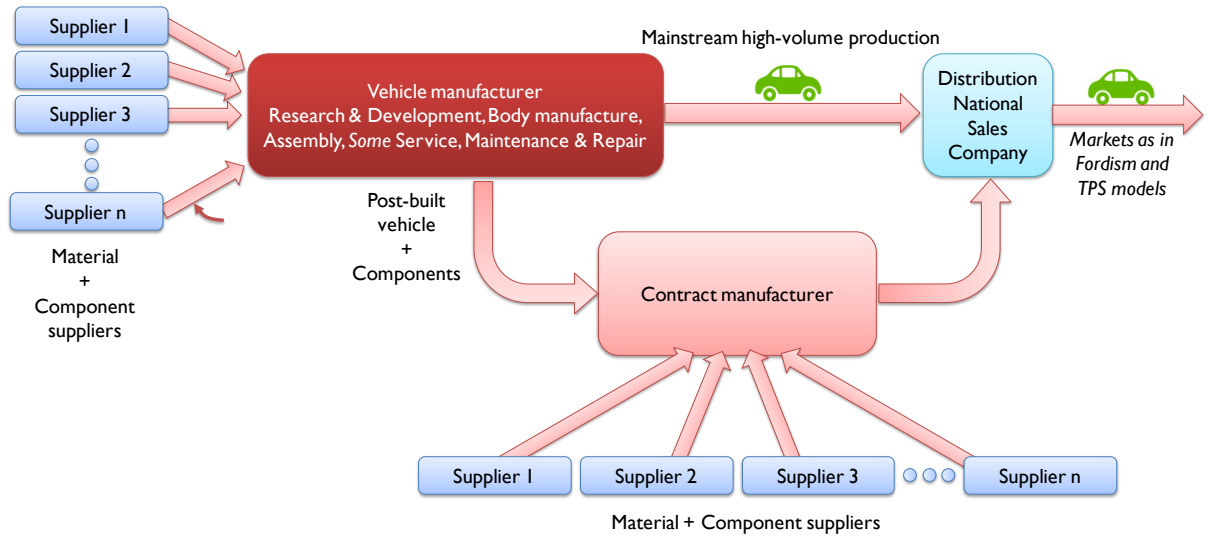


Figure 44 - The 'Contract Manufacture' Business Model as envisioned in (Wells P. E., 2010b, p. 118)

The following business model canvas sets out some of the generic features of the “Contract Manufacturer” [also known as “Contract Assembler”] Business Model Archetype.



VM = Vehicle Manufacturer  
CM = Contract Manufacturer

#### Business Model Canvas 5 - 'Contract Manufacturer' Archetype Business Model

Arruñada & Vázquez (2006) state the contract manufacture allows the client to concentrate on areas where they can create the most value: design, marketing and R&D.



One area contract manufacturers (CM) can add considerable value is where they contract to manufacture similar style 'variant vehicles' for a number of producers. Arruñada & Vázquez, (2006, p. 1) mention this more generically in relation to 'products'. The CM can then retain tacit knowledge relating to R&D and manufacture. A particular case in point is the 'retractable hardtop roof'. For many years, VM's have contracted CM's to make convertible versions of popular models. During the 2000's, the automatic, retractable hardtop roof was popularised [e.g. in Mercedes SL, Peugeot 206cc, VW EOS] and certain contract manufacturers were able to develop technical capabilities in this area. This adds considerable value for client manufacturers, as knowledge gained can be transferred (informally) from project to project and across client VMs. However, Arruñada & Vázquez, (2006, p. 1) are clear to point out that this can also be a 'double edged sword', as CM's may arrogate information and intellectual property in ways potentially harmful to the VM if it benefits competitors.

However, the role of the 'Contract Manufacturing' business model in the automotive industry may not be sustainable. Calabrese (2009, p. 15) notes that, in 2007, Karmann had a production capacity of 100,000 vehicles but only utilised 42% of this whilst maintaining a payroll of 7000 employees. It is also a similar tale at Pininfarina, with a production capacity of 80,000 vehicles, 62% capacity utilisation and a 3,000 strong payroll. Worse still, the situation at Heuliez where the production capacity utilisation represented only 24% of the 50,000 capacity. Kahl (2009) documents the decline of '*Europe's once glamorous contract manufacturing industry*', with Heuliez being placed into administration, Karmann passing into insolvency 2009 and Pininfarina effectively exiting the business (entering into exclusive production rights with Bolloré to produce an EV). Calabrese (2009, p. 15) writes that, in 2007, all of these manufacturers scaled back their development plans and sought fresh capital.

In other industries, 'brand owners' have chosen to outsource much of their manufacturing (Arruñada & Vázquez, 2006, p. 2), choosing instead to focus on activities that offer the most value. It is strange that, on the whole, the automotive industry has not developed along this pathway, Interestingly, when Vauxhall / Opel was under consideration for sale by GM, Magna, a parts manufacturer, who also

contract manufactured vehicles through their Magna Steyr arm, were a serious contender (Webb, 2009).

Synocus Group (2011) notes (in relation to management consultancy services provided to Valmet) that the “role of contract manufacturers quickly changed in the beginning of the 2000s, and [CMs have] to look for new niche segments to provide opportunities for growth.” Describing the transition of Valmet from a ‘contract manufacturer’ to a ‘full service provider’, Synocus Group (2011) describe Valmet as now employing an ‘orchestration based business model’.

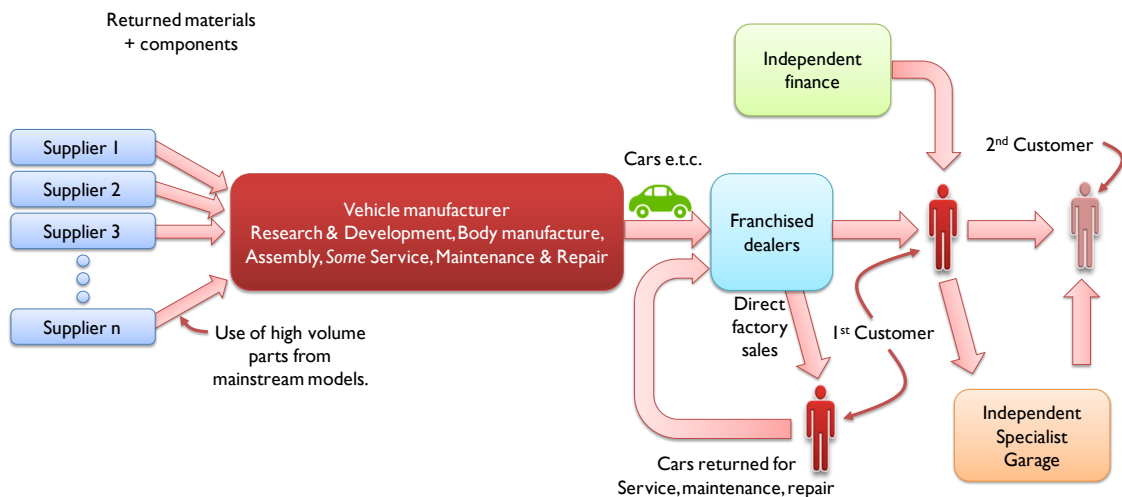
Arruñada & Vázquez, (2006) note that in some other sectors, CM’s, having acquired the confidence that they can manufacture a product, have sought to establish brand identities of their own and launch products, which then challenge those of the client they work for. In its extremist form, the example of IBM and Lenovo can be examined, where the PC manufacturing arm of a global ‘megabrand’ was ultimately taken over by its contract manufacturer. This type of positioning in the automotive industry may be seen yet. Calabrese (2009, p. 16) notes that major European CM’s have investigated the production and commercialisation of EVs under their own brand names as shown in Table 15.

<b>CM</b>	<b>Partner</b>	<b>Model</b>	<b>Type</b>	<b>Max. expected annual production</b>
<b>Bertone<sub>1</sub></b>	Jaguar	Jaguar B99	EV Sedan	Concept Vehicle
<b>Heuliez*</b>	French Government	Friendly	Small van	3,000 in 2010 then 10,000
<b>Heuliez*</b>	French Government	Will	Hatchback	5,000 in 2010, 50,00 in 2014
<b>Heuliez*</b>	Argentum	Pondicherry	Pickup	n.d.
<b>Karmann*</b>	EcoCraft	EcoCarrier	Small van	1,000 in 2009
<b>Karmann*</b>	DuraCar	Quicc DiVa	Small van	Up to 15,000
<b>Magna Steyr</b>	-	Mila	Vehicle platform	-
<b>Pininfarina*</b>	Bollore	Bluecar	Hatchback	Up to 15,000
<b>Valmet*</b>	Fisker Automotive	Karma	Sedan	Up to 15,000
<b>Valmet</b>	Garia	GolfCar	Low Speed EV	-
<b>Valmet</b>	-	Eva	2+2	Concept Vehicle

Table 15 - Some Electric Vehicles announced by European Contract Manufacturers

[Entries marked\* taken from (Calabrese, 2009) Updated with reference to (ElectroVelocity, 2011); (Cunningham, Wayne, 2009) (Valmet Automotive, 2011)]

### 3.5.2 Low volume specialist assemblers



**Figure 45 - The low volume specialist vehicle manufacturer business model as envisioned by (Wells P. E., 2010b, p. 119)**

Wells (2001, p. 4) notes the importance of scale in the automotive industry, stating that the highest efficiency plants worldwide produce one hundred cars per worker per year. Low volume specialist assemblers cannot compete on this level of efficiency, so they must look to create value for customers in other ways that allow them to command a premium price for their products.

The United Kingdom has a vast array of ‘smaller’ automotive firms, which produce specialist products that sell into a niche marketplace. Morgan (2011) cites a number of successful low-volume UK manufacturers and points to the UK engineering base’s **VALUE PROPOSITION** of “*making complex technical things that are well designed and engineered*”

Rhys (1989, p. 22) writing before the emergence of the UK Zero Emissions Vehicle Industry distinguishes between four types of smaller vehicle manufacturer in the UK motor industry:

- Quality up-market cars
- Prestigious luxury limousines or grand touring cars
- Sports cars
- London taxicabs

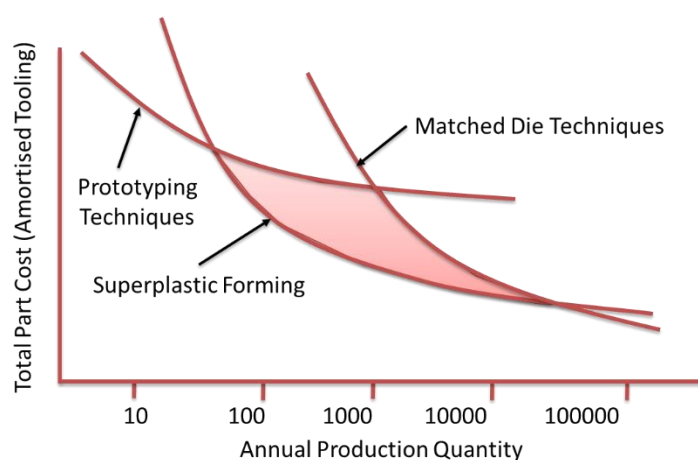
If the definition is broadened to include road vehicles other than cars, perhaps manufacturers of specialised commercial vehicles could be included. The development of zero emissions vehicles provides a new context and is perhaps another class of emerging small manufacturer.

Rhys (1989, p. 24) identifies one of the challenges to the small firm being the “shortage of working capital”, which presents an ever-present risk to the venture. This much continues to be true and ensuring cash flow is challenging for small firms, and often is the main reason that these smaller firms do not survive.

There is a distinctive character to manufacturing vehicles on a smaller scale. The processes and types of tooling differ dramatically. Rhys (1977, p. 250) noted that when Lotus commences its program of significant expansion, going public in 1968 and moving to new larger premises in Norwich, “*there was no attempt to ape the production methods and equipment of the mass producers*”.

Rhys (1977, p. 251) notes that low volume car bodywork production is often carried out in glass-fibre to avoid the need for the tooling associated with pressed steel. What is interesting is that, due to the oil content of plastic during the 1934-74 oil shock, the price of producing a glass-fibre body shell increased in the range of 25-30% compared to the increase in price experienced by pressed steel bodywork (affecting the relative competitiveness of big vs. small companies).

Now there are a range of techniques and processes, such as superformed aluminium, which have the potential to be attractive to low volume specialist assemblers. Figure 46, below, shows the techno-economic niche of this technology – the scale at which it is economical. Furthermore, through motorsport, there is growing experience in the industry of working with carbon fibre another technology suited to low volume, specialist assembly.



**Figure 46 – Superforming’s Techno-economic Niche (Superform, 2013)**

### 3.5.3 Kit car suppliers

Kit Car manufacturers have a unique **VALUE PROPOSITION** which is derived from carrying out a more limited number of **KEY ACTIVITIES**: the focus being on designing a vehicle that can be re-engineered from existing vehicle components and carrying out the manufacture of body components and perhaps other specialist components required to complete the build. Here, the customer is a **KEY PARTNER** in constructing the vehicle and the kit car manufacturer will require a more limited array of **KEY RESOURCES**, as the customer is usually involved in assembly. Kit car manufacturers are effectively component suppliers, who produce a limited number of key bodywork, chassis and specialist components and sell these with the intellectual property associated with a vehicle design that can utilise those specific components.

Kit car manufacturers may realise **REVENUE STREAMS** from the sale of vehicle plans, vehicle body components. Additionally, some kit cars can even attain cult status; (the UK's car culture is discussed on p.219).

Caterham was formerly a retailer of Lotus 7 cars. Lotus pioneered the approach of offering to the purchaser a CKD (Completely Knocked Down) kit of parts, which the user could then assemble. This practice continued until 1993 when pre-assembled vehicles were offered in parallel with the CKD kits (Rees, 2007, pp. 73, 83, 133,134). This shows that there can be a transition route for manufacturers to acquire and build capabilities as a kit car producer, and then grow to be a vehicle manufacturer.

The **CUSTOMER RELATIONSHIP** between kit car manufacturer and consumer are necessarily radically different. Wells (2010b) highlights that, in the Kit-Car business model, most of the value is added by the consumer, who is responsible for sourcing many components and providing much of the manufacturing base for assembling these components into the finished vehicle. Rhys (1989, p. 27) distinguishes between the mainstream kit car industry, where second hand components are sourced by the consumer / constructor and assembled into a vehicle, and those who manufacture 'new' kit cars [citing Caterham and Midas as examples during the 1960's], where all components required to assemble the vehicle are required 'as new'.

There are many limitations inherent in the kit car business model. There is only a small pool of enthusiasts with the requisite skills to assemble components into a finished vehicle and this limits the marketplace of kit-cars to being a 'niche' vehicle provider, appealing only to a certain **CUSTOMER SEGMENT**. There are, however, some advantages to this model for small scale vehicle production, with the "Conditions of free entry and exit" as described by Rhys (1989, p. 27) exist. Rhys (1989, p. 27), writing a retrospective view of the 1980's UK motor industry, described the UK Kit Car industry as "*the most dynamic part of the small company sector in the 1980's car industry*".

Historically, specific 'regime' level features supported the development of UK companies with a kit car business model. Kit cars circumvented 'purchase tax' (Rhys D. G., 1977, p. 249), which compensated significantly for the diseconomies of kit car manufacturers operating at a much smaller scale. One of the advantages of the kit car business model highlighted by Rhys (1989, p. 27) is the exemption from the need for "type approval" in many circumstances, circumventing the need for the safety testing regime new vehicles are subject to. A similar advantage is currently conferred on kit-cars which are exempt from the 'End Of Life' ELV Directive (ELVD) (Smith & Crotty, 2008, p. 344).

A rich and up-to-date description of the UK Kit-Car Industry is provided by Fletcher (2010), who discusses the basic tenets of the kit-car business proposition. He goes on to construct a history of the UK Kit-Car Industry from specialist insurance data, kit car owners clubs and the three kit-car magazines published in the United Kingdom (Fletcher, 2010, pp. 14-17).

The technology employed for kit car production is optimised for assembly using tools that can be procured by the "home workshop"; to this end, there are often compromises made where technically elegant solutions are eschewed in favour of practical simplicity for easy assembly.

As kit cars source many of their major components from donor vehicles, and then augmented with unique vehicle-specific components, Rhys (1989, p. 27) suggests that kit cars can be viewed as 'recycled cars'. Indeed, they can create a future, sustainable use for some used car components.

If a slightly more nuanced view of the waste management implications of the kit car industry is to be taken, it could be said that it is minimising the amount of vehicle waste through the re-use of major vehicle components, with the remainder of the host vehicle increasingly recycled through various initiatives. That said there are also waste management risks with kit cars; manufacturers are regulated and adopt compliant waste control procedures for their processes whereas home builders are harder to regulate and may not be as conscientious in their management of production waste.

There clearly exists some appetite amongst consumers for home assembly electric vehicles. The recently released publication 'Build Your Own Electric Vehicle' (Leitman & Brant, 2008) has enjoyed a significant amount of interest on Amazon.com. Whilst a very crude yardstick for comparison, the following table summarises the status of this book and two others targeted at the "homebuild ZEV" marketplace and benchmarks these against a number of other works considered seminal in the kit car arena. Amongst these are Ron Champions' 'Build Your Own Sports Car' series, around which a whole cottage industry has grown in the UK, producing pattern parts for a design of vehicle originally published in book form.

Book	Origin	Amazon.com Rank #	Amazon.co.uk Rank #	Amazon.com # of Reviews	Amazon.co.uk # of Reviews
<b>Build An Electric Vehicle Books</b>					
<b>(Leitman &amp; Brant, 2008)</b>	<b>US</b>	46,780	96,685	52	4
<b>(Brown &amp; Prange, 1993)</b>	<b>US</b>	243,133	1,030,118	28	0
<b>(Vogel, 2009)</b>	<b>US</b>	166,198	186,703	8	3
<b>Kit Car Books</b>					
<b>(Champion, 2000)</b>	<b>UK</b>	821,340	229,555	10	7
<b>(Ayre, 2008)</b>	<b>UK</b>	1,105,175	234,893	1	2
<b>(Tanner, 2005)</b>	<b>US</b>	73,038	234,032	27	1
Data Captured 15 <sup>th</sup> July 2010					

Whilst analysis of Amazon.com sales rankings on a single occasion is far from scientific, it does provide a very crude yardstick for the popularity of a given book; crude guides to interpretation of Amazon.com rankings can be found in Rosenthal (2010)

### 3.5.4 Design houses

There is a difference between ‘styling’ on the one hand, ‘design’ on the other and ‘engineering’. In each instance, it must be clear on the ‘value’ that is being added, whether that is in terms of improving the aesthetic of vehicles, usability or configuration, the operation, manufacturing or processes or the technical capability that underpins the vehicles performance. In all cases, the ‘design house’ business model acts as an intermediary in the value chain, adding value in terms of knowledge to the process of vehicle design.

In the embedded case studies considered, there are several examples of companies who leverage their design capabilities to help manufacture ULEVs. Consider the cases of Gordon Murray Design (seen on p.327) and Lotus (explored on p.338). Furthermore, there are others who offer ‘technical design’ input, such as ZYTEK, who design drivetrains and ULEV powertrain systems.

Taking an international perspective, there are also firms that offer car styling, designing the visual aesthetic of vehicles. Calabrese (2009), examining the Italian car styling industry, has observed how the “*digitalization of production*” combined with a changing dynamic to supply chain relationships has manifestly changed the strategy and positioning of companies in the Italian car design industry. In the same study, Calabrese (2009) points to an increasing collaboration between “manufacturers” and “coachbuilders” [for which in the context of this article it can read ‘styling houses’], with the latter seen increasingly as partners with whom to co-create vehicles.

In terms of the business model, whilst clearly a patriot, Calabrese (2009, p. 7) captures the essence of the Italian design house’s business model and source of the Italian styling industry’s competitiveness:

***Design could be the true value added to the product, capable of mirroring and fully expressing the Italian genius, which strives to harmonise beauty and functionality.***

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(Calabrese, 2009, p. 7)

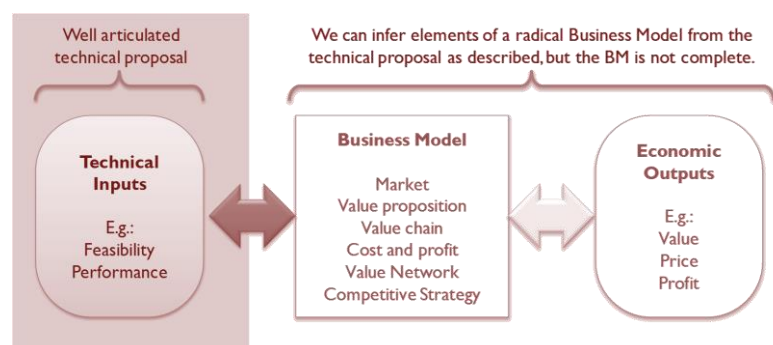


### 3.6 Radical Mobility Business Models

There are a number of radical personal mobility concepts which challenge the current view of how personal mobility is organised. This section is not 'exhaustive'; instead it aims to provide a brief cross-section of current business thinking on alternative business models in other markets as a capstone to this chapter's examination of the automotive industry's evolving business model. Some of these, like the GM/Segway PUMA, have arisen out of 'anticipatory planning practices' (Wells & Orsato, 2004, p. 273) that are ongoing within the automotive industry. Some have been proposed as disruptive technical solutions by those outside the industry, academics or entrepreneurs. In the case of the Ridek Concept (p.163), elements of this radically different approach to vehicle manufacture can be seen in the technical developments of BMWi (p.175).

A number of industry analysts, all of whom seem to indicate that radical changes to business models, may hold the key to the future of the industry. Rebecca Trengrove of Axeon has said (AWPresenter, 2010c) *"My personal view about where this all might go is that we will start thinking about a different way of achieving personal mobility"*. There is an expectation from some industry analysts, such as Dr. Wolfgang Bernhard, that there will be significant growth in 'non car' segments of the vehicle industry (AWPresenter, 2010d). This perhaps hints at a consumer readiness to look at different ways of delivering transportation.

However, whilst there are some proposals for radically different business models in their entirety, there are also some concepts for radically different technologies and conceptions of automobility. Whilst there is a well-articulated proposal of how the technology might operate, there is less clarity about the business model that will bring these technologies to market (as illustrated in Figure 47)



**Figure 47 - Some proposed future vehicle technologies imply a radical business model, even if this has not been well articulated (after**

### 3.6.1 Tesla

Tesla is notable as perhaps the most credible challenger company in the marketplace, developing electric vehicles at the moment. Tesla was born out of knowledge from Silicon Valley concerning how to increase the battery life of portable electronic devices. This resulted in one of Tesla's key resources that has given it the edge over the incumbent industry in developing new electric vehicles; namely, advanced knowledge in relation to the charging, utilisation and battery management of rechargeable batteries. The characterisation is a simple one; the automotive industry as a whole is used to working with larger batteries. Tesla's insight was to realise that working with an array of smaller batteries and smart electronics meant that more power and performance could be extracted, resulting in increased vehicle performance (Masson, 2013; Tesla, 2012).

Its first vehicle, the Tesla Roadster, is discussed later as it features in the Lotus case study sharing some of its engineering with Lotus vehicles and was made under a contract manufacture arrangement. Tesla has used this vehicle as a springboard and has now built its own manufacturing capacity and developed the Model S saloon vehicle.

Within the US marketplace, there are state-by-state mandates for introducing ZEV zero emission vehicles, which is an evolution of the policy work done in California. Automakers are fined if they do not meet targets, or alternatively they can buy credits from other companies such as Tesla with an excess of credits. Greiling & Ohnsman (2013) note that Tesla earned \$85 million selling credits in the first quarter of 2013 to other automakers for the Electric Vehicles that they are producing.

A very recent announcement by Tesla (2014) is their plan to build a "Gigafactory" to produce Lithium Ion Cells. This factory by 2020 aims to produce more Lithium Ion batteries than GLOBAL production in 2013. This is equivalent to 35 gigawatt hours of battery capacity being manufactured every year. It is a completely game-changing move by the company given how important battery supply is to electric vehicle manufacture. Furthermore, in addition to massively increasing the quantities of Lithium Ion batteries, the Gigafactory concept includes an array of features that may make the manufacturing of Lithium Ion batteries more sustainable, including power for the plant sourced from renewables.

***“This will allow us to achieve a major reduction in the cost of our battery packs and accelerate the pace of battery innovation [...] With this facility, we feel highly confident of being able to create a compelling and affordable electric car in approximately three years.”***

**Tesla (2014)**

The projected figures for the decrease in cost are for a 30% reduction in battery cost by 2017 and a 50% reduction in battery cost by 2020.



**Figure 48 - Tesla Gigafactory**

Savenije (2014) questions whether Tesla will remain a car company or whether this massive expansion in Lithium Ion battery manufacturing will potentially take the business in other directions.

***“We are witnessing the most disruptive intersection of manufacturing, innovation and capital experienced by the auto industry in more than a century [...] Tesla may be in position to disrupt industries well beyond the realm of traditional auto manufacturing. It’s not just cars.”***

**Adam Jonas, Automotive Analyst for Morgan Stanley quoted in Savenije (2014)**

More recently, Tesla have challenged the idea of automotive dealerships, with a concept of sales direct to the consumer through ‘Tesla stores’, This strategy has been championed by Tesla’s VC of sales, George Blankenship (Lavrinc, 2012), who had formerly worked at Apple and set up the successful

“Apple store” format. Unsurprisingly, this has received an angry reception from dealerships (Lavrinc, 2012) and organisations such as the US National Automobile Dealerships Association (NADA) who represent them (Berk, 2013) and have filed challenges in US state courts.

*There is a phase, after the early adopters, where you have to help people to compare and understand the benefits of electric drive versus gasoline power," O'Connell says. "We believe we're best suited to doing this because, in a traditional dealer environment, the bread and butter of an auto dealer is selling traditional technology."*

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Diarmuid O'Connell, Tesla's vice president of business and corporate development quoted in Berk (2013)

*There are several good reasons for our choice. The key thing is that we can talk directly to our customers, and give them the level of service that they deserve and that we expect. It wouldn't be the same with dealerships, who have, with fairness, to push other cars. So, you imagine a normal customer going into your normal car dealership, and your normal salesperson working on commission, if it looks like it's going to be a difficult sell to sell the [electric car], for example, to that consumer, they're going to push them towards the more conventional car which is the easier sale to do. It's the same with us, if we have our cars next to the [high performance ICE car competitor], if it's going to look like a difficult sale; rather than work around it with the consumer, they're just going to walk past and sell something else. So those two good reasons; we don't think we're represented correctly because of the commission based system that dealerships operate, and how they compete, and also we want to offer a completely different level of service.*

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*In the US, they do things very differently in terms of delivery. Rather than going to the dealership and picking up your car etc., we have a 'delivery specialist' who will talk you through when your car is arriving, when it's available and maybe home deliver it for you. They can also spend an hour or so taking you through the car, and how it works etc. We give that as a delivery experience, which is not something that you wouldn't get from standard dealership platforms.*

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That said, Tesla isn't ruling out the possibility of establishing a franchised dealer network if volumes of car sales grow to hundreds of thousands per annum.

### 3.6.2 Tesco Cars

Tesco cars was an attempt by the UK based multinational supermarket chain Tesco to enter the sphere of vehicle retailing. They attempted to innovate the automotive business model, by offering direct B2C sales of used fleet and Motability cars. This was done in part through their online website, pictured below in Figure 49. With Tesco's massive presence in retail and a tremendous customer database, there were some significant assets that could be leveraged. Despite this, the business failed in April 2012 (Seymour, 2012). Commentators put the failure of the business down to an inability to source used car stock, the lack of a part-exchange option and the lack of a physical presence / ability to take cars for a test drive leading to a poor customer experience (Seymour, 2012). Perhaps here is a cautionary tale as, whilst many pundits predict new digital models of retail and innovative "lifestyle" retailing formats, for a purchase that is as expensive as a new vehicle, the physical, tangible experience of the product is still essential for customers.



Figure 49 - Tesco Cars Screenshot

### 3.6.3 Local Motors

The Local Motors business model is a radically new business model for vehicle manufacturing that places the consumer at the centre of both the design and manufacturing process. Local Motors targets a **CUSTOMER SEGMENT** of technically literate customers with a passion for car design and customisation (Norton & Dann, 2011). Whilst it is hard to see the 'Local Motors' model ever becoming a mainstream model for mass car manufacture, it is clear that there is room to grow the niche in which Local Motors operates and there are a number of significant unique features to their business model which will be briefly outlined here.

The customer relationship in Local Motors business differs dramatically from the traditional automotive industry (Wulfsburg, Redlich & Bruhns, 2011). Rather than the customer being a passive recipient of the industry's design i.e. a 'product push' onto the customer, Local Motors' product development is driven wholly through "consumer pull". This constitutes the core of Local Motors' very unique **VALUE PROPOSITION**. Vehicle design is "crowd sourced"; that is to say a large community of people, enabled by Web 2.0 technologies, contribute to the design of the vehicle through an open platform (Norton & Dann, 2011). Later, this thesis will see some elements of this in Riversimple's '40 Fires Foundation'. This is interesting concept, as it repositions the customer as both a **KEY PARTNER** in car design and creation, with the knowledge and preferences that the customer brings to the car design process being considered as one of the company's **KEY RESOURCES**.

The way that the company performs its manufacturing also differs dramatically from the mainstream industry. It has much in common with other low volume vehicle manufacturers but the involvement of the consumer in vehicle manufacture is a significant variation in the conduct of this **KEY ACTIVITY**.

Fox (2012) describes this as "Factory 2.0" but many elements of this business model have been discussed by Wells (2001) and Wells & Orsato, (2008) under the heading of 'Micro Factory Retailing'

Not all customers have the ability to build their own vehicles. However, what is most interesting is the way that the **CUSTOMER RELATIONSHIP** changes with their opinions being brought into vehicle design; becoming a co-creator of the product rather than just a passive recipient.

### 3.6.4 Ridek Concept

One solution proposed and advanced by Dower (2002) to overcome the limitations of different drivetrain technologies is to separate the vehicle into two components: the drivetrain and chassis; known as the 'modek' (no connection with the electric commercial vehicle Modec, see page 346), and a cabin which "rides" on the modek, known as the 'ridek'. Ordinarily, a user could employ an electric ridek for the majority of urban journeys; however, if longer inter-urban journeys were required, the user could exchange the ridek for one with an internal combustion engine at a 'ridek exchange station'; which could possess elements of automated functionality in the style of current PBP refuelling stations. Wells & Orsat,(2004) describe the Ridek as an *"innovative product design [which] can also liberate an innovative approach to vehicle ownership and use."*

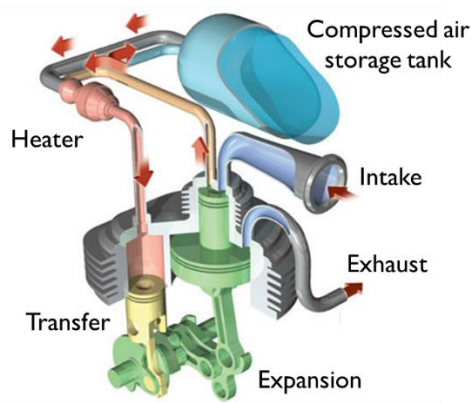
In an interview, Rebecca Trengrove of Axeon (AWPresenter, 2010c) raises concerns over a Ridek-type vehicle, where the vehicle is divided into a "publicly owned" powertrain, and a "privately owned" chassis. Trengrove highlights some of the challenges of differential wear in the two components, as well as the cost and accounting challenges in valuing the two components. She cites these challenges as common to a range of "swapping" business models. The Ridek represents a 'technical' solution to what might be termed a 'social' problem. Many consumers, because of the large investment, purchase general-purpose vehicles to meet a variety of different applications.

Mainstream vehicle design, as presently conceived, does not permit the modularity or flexibility that a design solution would permit and, as such, there is no allowance made for "differential obsolescence" of different vehicle parts. In the 'Riversimple Case Study' (See page 349) it can be seen how an innovative business model can begin to answer this challenge. Wells, 2010b, p. 17) discusses the product lifecycles on which the industry operates, with a new model taking 36-48 months to transform from the 'drawing board' to bring to market, being in production for 8-10 years (with product lifecycle extended through 'facelifts' and redesign) and then being supported in the aftermarket for an additional decade. BMWi vehicles (see page 175) shares some distinct similarities with the Ridek concept technically, considering the separate "Drive" and "Life" modules.

### 3.6.5 MDI Air Car

Compressed air is already used in a variety of applications as an energy vector. In the automotive arena, compressed air is commonly used in a variety of vehicle maintenance applications, providing the power for tools and some processes. Another potential benefit of compressed air as an energy vector is that the simple design of the drivetrain components should ensure a long service life for components (Wells P, 2002). This increases the product's sustainability by virtue of this long shelf life and gives this technology a potential edge over battery and fuel cell technologies in this respect.

Storing energy in the form of compressed air however, presents several challenges, compressed air as an energy storage medium, is even less energy dense than battery technologies. This severely constrains the **VALUE PROPOSITION** of compressed air powered vehicles. This is offset by the relative cheapness of compressed air storage, compared to battery storage. Furthermore, the compressed air engine technology shares broadly similar manufacturing processes with internal combustion engines – being also of a reciprocating piston type engine, as shown in Figure 50 below.

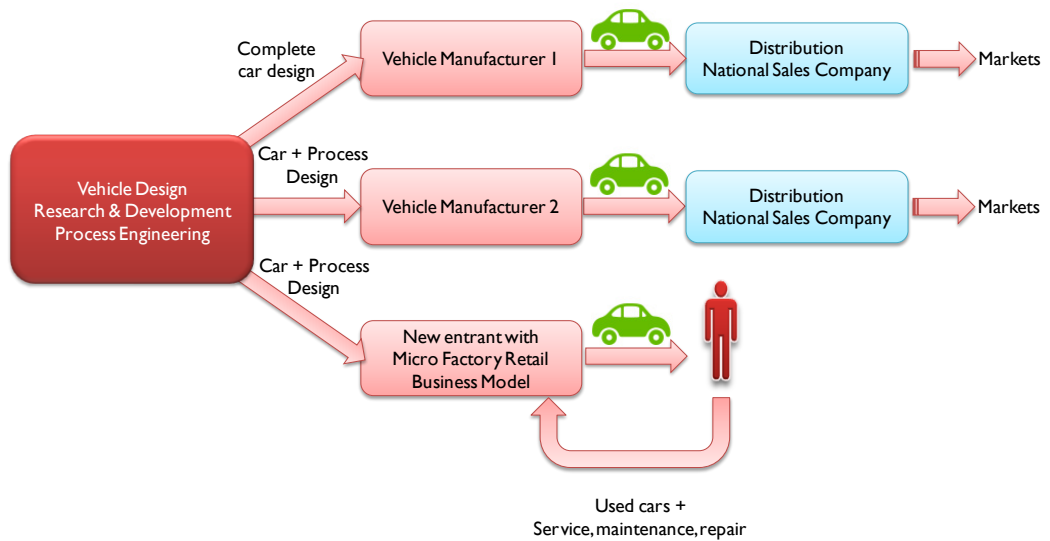


**Figure 50 Compressed Air Engine, Redrawn from Steiner (2008).**

One aspect of the MDI business model that is noteworthy is the 'licensing' approach (Wells P., 2002), which intended to promote the spread of the technology internationally. MDI has designed a standardised factory, equipped with space to manufacture the vehicles, administrate the business and sell the vehicles. An analogy could easily be made with the 'franchise' model used by many retail fast food vendors where a 'standard design' of restaurant is sold to franchisees along with all of the equipment and processes to produce the end product. In return for the investment resources for the



venture, investors or franchisees are granted a 'territory'. There is some commonality between the licensing approach considered by MDI for its air car and Gordon Murray's 'iStream' concept (on p.327).



**Figure 51 - The MDI Business Model (Wells P. E., 2010b, p. 124)**

Whilst the air car is an interesting technology, it is constrained by technical limitations and has not reached the market; however, there have been discussions with TATA about licensing the technology. In 2007, (Steiner, 2008) they invested €20 million in MDI, with a view to licensing the technology for use in India.

### 3.6.6 Tata Nano

The Tata Nano is a vehicle that has aimed to disrupt the marketplace for vehicles in developing countries by being the cheapest new car available (Nair, 2012). Whilst the Tata Nano does not employ any advanced technologies, it is interesting from a business model perspective, as it is a product designed to target a value segment for which the industry has not traditionally designed products. The car has been promoted as the least expensive production car in the world. Tata has sought every attempt to engineer cost out of the vehicle (Spiegel, 2008). However, Nair (2012) notes that sales performance has not matched expectations; consumers perceived the car as cheap, with a better specified second hand vehicle attracting more social cachet.

From an environmental perspective, there is a paradox. The Tata Nano has lower emissions than the average VW (Spiegel, 2008), however, in reaching a new segment they have the potential to encourage consumption in fast developing markets.

Tata designed the car in such a way that an extensive infrastructure of dealerships was not required, as the car could effectively be built in “*village garages*”. (Nussbaum, 2008) The sourcing of parts for the vehicle is also an interesting departure from traditional automotive industry logic, using ‘reverse auctions’ to source parts suppliers (Nussbaum, 2008).

“Reverse innovation” is the practice of developing limited feature products that can be sold at a low cost in order to satiate local demand (Govindarajan & Ramamurti, 2011). Whilst innovation is often thought of as “trickling down” from wealthier segments to lower segments, in reverse innovation the potential for innovation to “trickle up” from poorer customer segments to richer ones is considered.

It is interesting to consider the difference between the Tata Nano business model which seeks to develop a very cheap vehicle for emerging markets, with the GM En-V concept discussed next, which is a very advanced vehicle for megacities in emerging markets. Both position their business model to capture value from customer segments in these fast developing countries, however, they take different approaches and target different customer segments within these markets.

### 3.6.7 En-V GM / Segway Personal Urban Mobility & Accessibility –AUTOmomy project

The En-V GM Segway PUMA / AUTOmomy project aims to address the problem of rapidly growing megacities in the developing world and the demand for personal transport. It starts from the perspective that the population density of these mega cities is already incredibly high. Furthermore, their private transport systems are dysfunctional with traffic chaos and a lack of space for parking. AUTOmomy aims to “shrink” the vehicle to a much smaller unit capable of carrying two passengers in comfort. In turn, it uses smart technology to ‘balance’ on two wheels in the manner of the Segway. Mitchell, Borroni-Bird & Burns (2010) set out a detailed case for the EN-V vehicle in their book.

Chris Borroni-Bird states that average industry foresight stretches ten years into the future; however, the aim of the AUTOmomy project was to forecast demand further into the future, with a twenty-year horizon providing the project with a ‘clean sheet’ approach to looking at consumer needs. GM was working with SAIC as a strategic partner (Motavalli, 2010) and launched the concept at the Shanghai Expo. Borroni-Bird speaking to Wilson (2010) said that the concept diverges so much from our present understanding of vehicles that *"we probably shouldn't even call it a car"*.

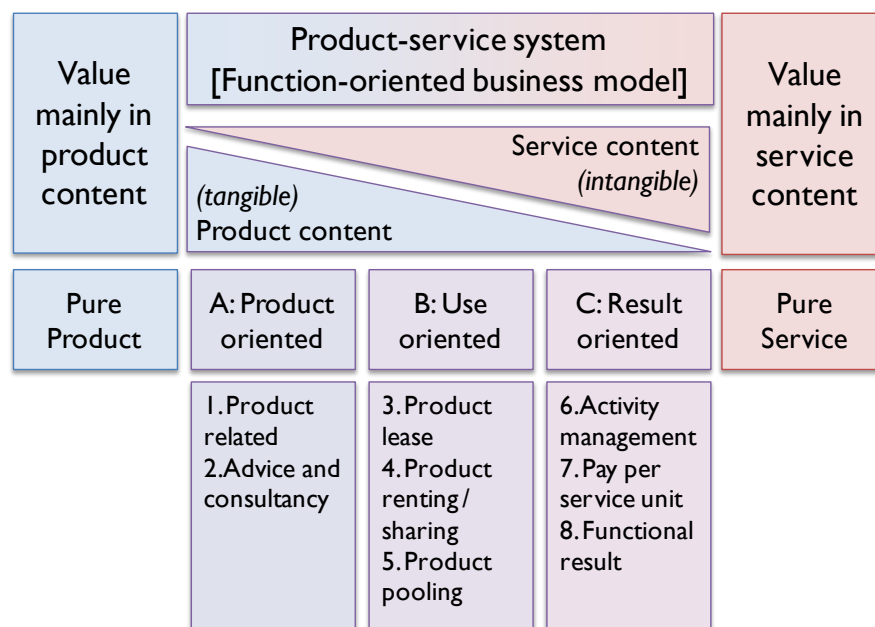
The vehicle offers an interesting value proposition of lithium-ion batteries that can be charged from a standard socket (Motavalli, 2010). As the vehicle is much lighter, it requires a smaller battery pack. Another interesting diversion is that the vehicle uses differential speeds of the two wheels to both steer and brake, making the vehicle entirely drive-by-wire, even to the extent the driver need not be in control as the automatic systems can steer and navigate the vehicle in some circumstances.

In addition to being concerned with vehicle emissions in large urban areas, the AUTOmomy also attempts to address some of the social issues surrounded with vehicle use (AWPresenter, 2010), through addressing concerns of congestion through advanced telematics and connectivity.

Here, the advanced technology employed by the vehicle completely changes the technology’s value proposition. Furthermore, such an innovative vehicle with such a great deal of connectivity will require a different business model to support its development.

### 3.6.8 Envisioning Mobility as a Function Oriented Business-Model (Product Service System)

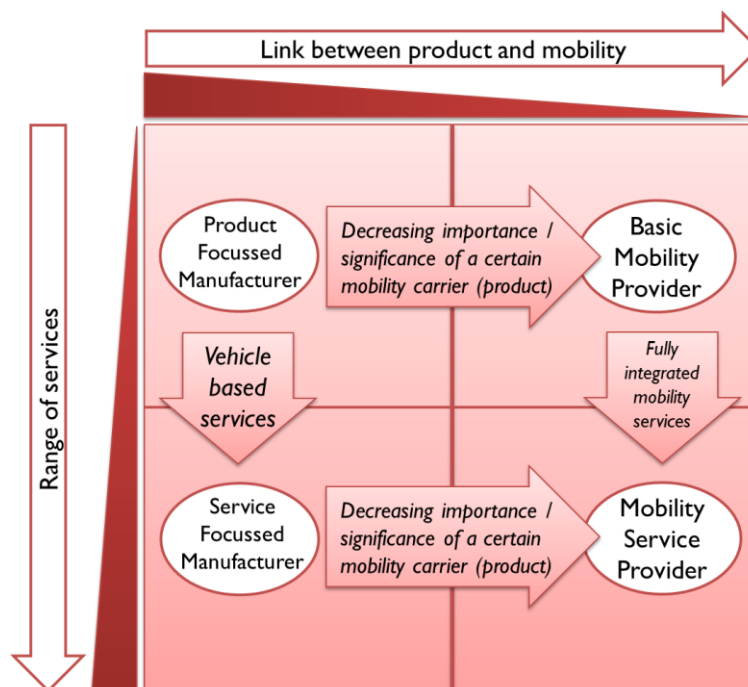
One of the most radical suggestions for a re-conception of the customer relationship that VMs have with the customer is in the idea of conceiving mobility as a service, rather than a car as a product to be bought. This is conceived of as a product service system and would imply a ‘function oriented business model’; the function being to supply mobility to the consumer as opposed to a product oriented business model which focuses on selling cars to consumers. A review of the recent literature in product service systems can be found in Tukker & Tischner’s (2006)’s study which identifies eight subclasses of function oriented business models presented in the Figure below.



**Figure 52 - Main and subcategories of PSS - From (Tukker A. , Eight types of Product Service System: Eight ways to sustainability? Experiences from SUSPRONET, 2004)**

If at one end of this continuum, there is the industry’s present business model then at the opposite extreme there is a dematerialised model of mobility consumption, where the function of the business may grow to include the provision of, not only the physical artefact, but also perhaps to include energy and additional services. It can be seen globally how concepts such as [Project] Better Place (see Page 133) aimed to radically change the way that mobility was consumed, drawing into the industry a much greater array of stakeholders than is currently present in the industry.

According to an Arthur D. Little report, which forecasted automobility trends to 2020 (Winterhoff, Kahner, Ulrich, Sayler, & Wenzel, 2009, p. 11), there are a number of trends – some of which we have already discussed – which will lead to a move away from product focused business models. Little predicts that users will require enhanced levels of mobility, innovation and sustainability but will be less willing to invest money in obtaining this. Predictions about the future of the automotive industry centre around four business models. The factors that discriminate between them are presented in the figure below.



**Figure 53 - Model of the Mobility Market in 2020: Idealised Business Models (Winterhoff, Kahner, Ulrich, Sayler, & Wenzel, 2009, p. 11)**

Here, the ‘Link between product and mobility’ represents the degree to which provision of mobility services is tied to a specific physical product or vehicle, whilst the ‘range of services’ encompasses:

***“further mobility, convenience and lifestyle services [...] either directly connected with mobility (e.g. traffic or parking guidance systems), or otherwise overarching services which the customer can use during the actual mobility time (e.g. online shopping, office support, etc.).”***

**(Winterhoff, Kahner, Ulrich, Sayler, & Wenzel, 2009, p. 11)**

In the business models that follow, what is interesting is how the ideas of some elements of the mobility package being conceived of as a “service” are starting to enter the market awareness.

### 3.6.8.1 [Project] Better Place



Figure 54 - A Project Better Place Business Model Interpretation by Fielt (2010) of Davies, Brady, & Hobday (2006)

The Project Better Place (PBP) initiative as a business failed when PBP filed for bankruptcy in 2013 (Kershner, 2013). This has also impacted on PBP's partners, in particular Renault, who had based their vehicle strategy going forward around PBP's innovative technology (Pearson & Toth Stub, 2013).

Project Better Place was a business initiative to improve on the value proposition of electric vehicles by shortening the time it took them to 'recharge'. The technical solution it deployed was a novel "battery swap" system, where the user drove into a recharging station, not unlike the experience of a car-wash, where the battery of the vehicle was removed robotically and exchanged. The idea of 'battery swap' technology can be seen in the value propositions of some other niche manufacturers [See Modec Case Study p.346] however, technologically, PBP improved on this offering by automating the process of battery swapping. Also, the business model negated the high initial capital cost of batteries:

***It's a subscription system much like cellular providers have. You sign up for a certain number of miles a month.***

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**Shai Agassi, Better Place Founder quoted in (Meenakshisundaram & Shankar, 2010, p. 2)**

There are a number of challenges to the battery swap business model. Some of these are technical, for example, the challenge of designing a universal standard for batteries to work across a range of vehicle platforms, whereas others were logistical, like the stocking a range of batteries for a range of models.

Rebecca Trengrove of Axion (AWPresenter, 2010c) highlights some of the challenges of integrating battery-swap technologies into vehicles. Given the technical challenges of packaging high-energy density batteries into a range of different vehicle platforms and configurations, Trengrove intimated that the idea was “*a bit of a non-starter*”

***“The challenge faced by the battery swap business model is the need for vehicle manufacturers to agree on a small number of consistent battery specifications, which would be necessary to make this a feasible solution.”***

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**Neil Butcher, Arup (Project Leader CABLED) (Sunderland, An interview with Arup, 2010)**

PBP listed amongst its locations for potential locations: Denmark, Israel, Australia, Japan, Ontario and Hawaii (Garthwaite, 2009). These locations were selected based on demand for the technology – where there was support, and local buy in from the large number of stakeholders required to make a PBP type business model a success. The drivers for electrification of transport in location like Israel & Hawaii, being ‘energy islands’ is clear. Trying to develop the venture in many different limitations simultaneously, may have overstretched PBP and been a contributory factor in the project’s failure.

Overleaf are two diagrams from different sources and in different formats but both illustrate the same point; PBP aimed to create value by acting as an “integrator” and bringing key partners together to deliver an innovative electric vehicle value proposition, whilst managing the relationships between a range of different key partners.

Project Better Place would then manage the customer relationship, providing a service point for those seeking battery recharge but would create that value for the customer (and also importantly for key partners) through managing a series of complex interactions. Cheslow (2013) positions lack of consumer uptake as the main reason for the failure of the PBP business model. As the number of drivers began to diverge from predicted sales, investors lost hope and the business models’ predictions of success began to look increasingly flimsy to industry commentators.

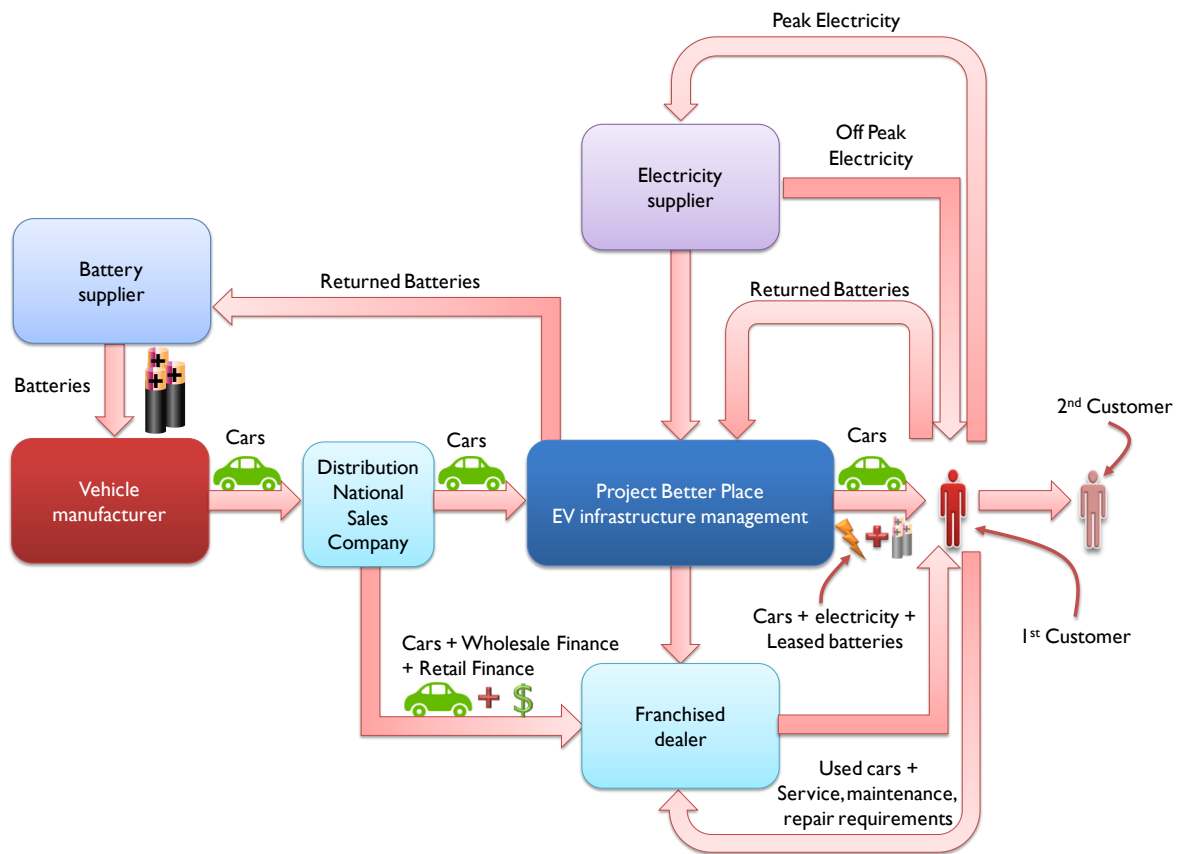


Figure 55 - The Project Better Place Business Model as envisioned by (Wells P. E., 2010b, p. 127)

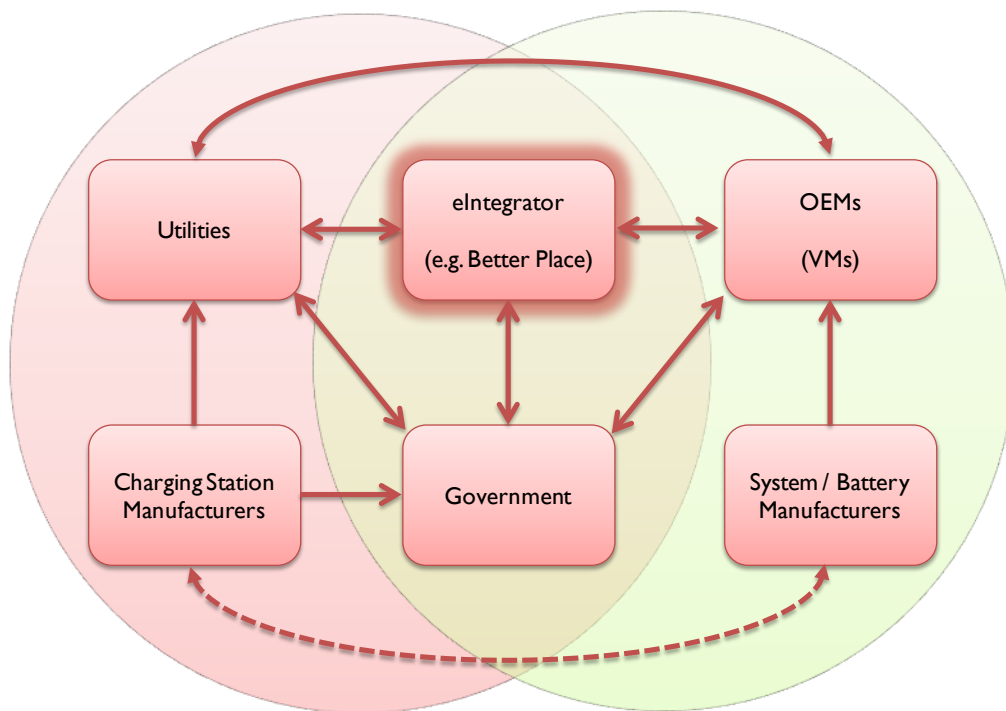
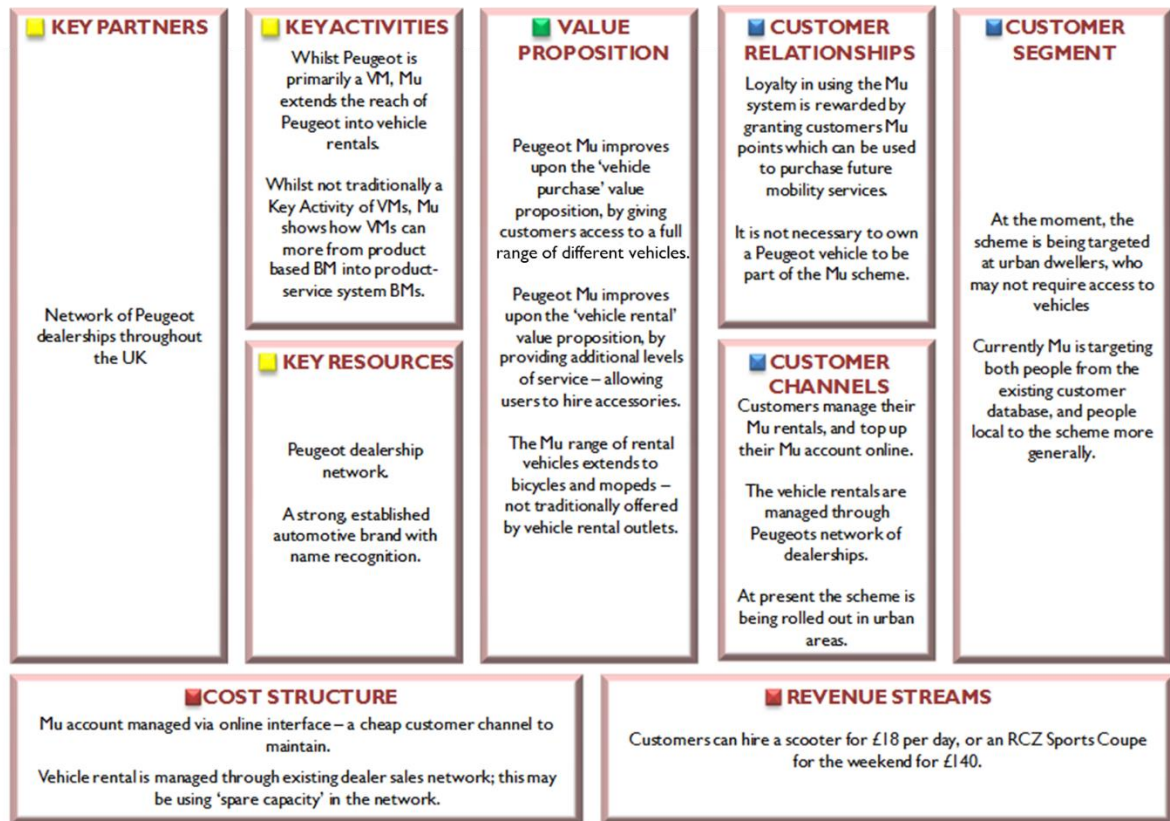


Figure 56 - Positioning in the Value Chain of Better Place's Integrator Business Model – Redrawn from (Singh, 2011)



### 3.6.8.2 Mu by Peugeot



**Business Model Canvas 6 - Mu by Peugeot Business Model**

Mu by Peugeot is being billed as a “mobility services offer” and enables clients, irrespective of vehicle ownership, to access ‘mobility services’ via a pre-paid card that can be charged on the internet (Peugeot, 2010). Originally pioneered in five French cities (Paris, Lyon, Brest, Nantes and Rennes) (Diehlmann & Hacker, 2013, p. 157), in the UK, Mu has been piloted by two dealerships in London and Bristol (Leggett, 2010).

In addition to providing the flexibility of offering the customer a choice between eighteen vehicles (of which some are light commercial vehicles (Leggett, 2010)), two scooters and two bicycles (Diehlmann & Hacker, 2013, p. 157), Peugeot differentiate this business model from traditional vehicle rental by offering an enhanced **VALUE PROPOSITION** through providing additional service. This can be through provision of accessories, such as roof boxes (Leggett, 2010), snow tyres, ski boxes and GPS (Diehlmann & Hacker, 2013, p. 157) for which customers may only have occasional use. Furthermore, all of the vehicles in the Mu scheme are said to be less than six months old. In terms of the customer segments, Peugeot is targeting both existing Peugeot customers from their customer database and

people who live local to the trial schemes. Where the scheme is of particular interest is in including a range of electric vehicles: The Peugeot Ion, the e-City electric bicycle and electric moped, e-Vivacity (Diehlmann & Hacker, 2013, p. 157). This can give apprehensive users the chance to experience electro-automobility without the risk of purchasing a vehicle (Berkeley, 2012).

Some have challenged whether the scheme is particularly radical. The “*Glorified rental scheme or clever marketing initiative?*” is the question posed by (Leggett, 2010). What is clear is that it is radical for a TNC/MNC VM to be offering this sort of value proposition and, as a business model component; Mu could help Peugeot address common customer concerns about range anxiety (see page 221) and the suitability of an electric vehicle for meeting a wide range of applications. Leggett (2010) also advances the notion that Mu could be a clever sales tool, creating ‘Mu points’ may be the necessary leverage dealers need to clinch sales, especially in transactions related to ULEVs where customers are concerned that the product may not fulfil their full range of transport needs.

### **3.6.8.3 Zipcar**

Zipcar is an example of another business, which is an innovative service system business model through car sharing. It leverages smart technology to allow vehicles to be collected from a wide range of locations rather than a central depot. Smart technology permits access to and computes the mileage and usage of vehicles. Whilst car sharing increases access to motor vehicles (which is generally seen as being inferior in sustainability terms when compared to public transport), it has been seen, where implemented, to reduce the private “ownership” of vehicles (Bieszczat & Schwieterman, 2012, p. 37).

Wunker (2012) notes that in defining the space of the Zipcar business model, they have in turn made it difficult for new entrants to that space, even if the approach is from established rental brands (transitioning from an old business model), such as Hertz with their Connect service. The Zipcar case also sheds light on another of the enduring questions examined in this thesis; one concerning the relationship between insurgents and incumbents – do new business models just get acquired by established large businesses, as has been the case with Zipcar being acquired by AVIS Budget, an established company?

#### **3.6.8.4 BMWi**

The BMWi business model is particularly interesting as it contains elements of both product service systems but also great changes to the key activities of vehicle manufacture. Commentators such as Kaye (2013) have said that *“BMW, could very well redefine the very concept of what an automobile manufacturer is”*.

Roth (2012) explains the change in focus of the BMWi business model from the perspective of the demographic transition that is predicted to occur in 2017, where the buying power of the “millennial” generation is believed to overtake that of the “baby boomers”, who are the dominant group who have hitherto shaped the market until now. Roth (2012) notes growing awareness in this demographic of issues concerning the environment and consumption. Roth (2012) notes the decline in teens opting to take a driving license and notes a range of different statistics that highlight that the consumption behaviours of this generation may differ from those that went before, stating that this is a significant challenge for the motor vehicle industry. The challenge, as Kaye (2013) puts it, is for automotive brands to *“stay relevant in the lives of consumers who do not have a car”*. These factors weighed heavy in the mind of BMW Norbert Reithofer, who initiated the programme for research and development that led to the BMWi brand (Reiter, 2013). The launch of MINI E electric vehicles for “business modelling” purposes was part of the BMWi trial.

Singh & Briggs (2013) note how the BMWi brand was launched, however, for some time it was unclear what business model would underpin the new brand. They note the BMW group’s primary strategy objective was *“to become the leading provider of premium products and services for individual mobility”*. What is particularly interesting about this strategic aim is how the objective is not wholly couched in the language of vehicle manufacture but clearly demonstrates an openness to alternative business models.

Singh & Briggs (2013) note that, in addition to BMW’s role as a vehicle manufacturer, they have also made investments in a range of allied products and services that support urban mobility but also hint at new directions, revenue streams and business models for the VM. They note investments in *“car sharing (DriveNow & Alphacity), a private parking space rental platform (ParkatmyHouse), a city based*

*infotainment application (MyCityWay) and a full suite of 2 and 3 wheeler micro mobility products like the ePedelec and eScooter.”*

In Roth's (2013) interview with Uwe Dreher, BMWi Global Head of Marketing, it becomes clear that the BMWi business model diverges from the traditional vehicle manufacturer business model in focusing more on “mobility services” than sale of cars. What is clear is that, whilst this business model aims to make access to cars easy and affordable, its focus is still squarely on the premium sector. Uwe Dreher (in Roth, 2013) points to the changes in consumption behaviours of the mega-wealthy in global cities. He states that there are those who would be living in a \$5 million home but driving a \$35,000 Toyota Prius, and notes how this was a signal to BMW that the market was changing.

What is fascinating about the BMWi concept is that the vehicle is divided into an aluminium chassis, the “drive module”, and a carbon fibre bodyshell, the “life module”. This shares many similarities with the “Ridek” concept discussed in this Chapter on p 163.

The use of carbon fibre to make the life module is also a radical change for a volume vehicle manufacturer. As a material, the handling and manufacturing processes are radically different than the sheet metalwork that the industry presently employs. Reiter (2013) notes that BMW is alone amongst mass car manufacturers in making the change to carbon fibre for its electric vehicle. However, as Kaye (2013) observes, the lightweight bodyshell improves the value proposition of electric vehicles, offsetting weight of battery packs and helping the vehicle achieve a low centre of gravity and improving driving experience. This comes at a cost; Reiter (2013) cites Frost & Sullivan data as saying that carbon fibre costs \$20/kg vs. a cost for steel of \$1/kg. However, as other proponents of carbon fibre, Professor, Stephen Cousins & Hugo Spowers (interviewed as part of this research) have noted a kilo of carbon fibre has a much greater utility than a kilo of steel and so the metric is open to challenge. According to Reiter (2013) it is the aim of BMW for carbon fibre to be cost competitive with aluminium by the year 2020.

BMW's plans for carbon fibre are very significant, amounting to 10% of the global market of the material (Reiter, 2013). To meet this demand, BMW have created a vertically integrated business,

where they produce their own carbon fibre. This marks an interesting choice. Aravind Chander, an analyst with Frost & Sullivan, has said (Reiter, 2013) “*BMW’s approach recalls the days of the industrial revolution, when manufacturers started with raw iron ore or located factories near power sources [...] It’s an aggressive approach and still unproven.*”; however, perhaps this is just a repetition of Henry Ford’s early vertical integration at the River Rouge plant where raw materials are produced on site.

There is also an interesting key partnership. The carbon fibre plant is located in an unlikely part of Washington State; however, the plant is based near the Colorado River, where there is an abundant supply of hydropower for which the local utility will charge 3 cents / kilowatt hour, a fifth of the price the same renewable energy would cost in Germany (Reiter, 2013). BMW were keen to make sure that the plant was powered from renewables to make the production of carbon fibre congruent with the environmental values of the brand.

However, Uwe Dreher is quick to assert that the “*core of the brand*”, the main BMW value proposition remains unchanged: “*sheer driving pleasure*”.

### 3.7 Chapter Summary

This chapter took the theoretical concept of 'business models' and grounded the concept in the context of the automotive industry. It developed the literature review, which focused on the more general theoretical field of 'business models' by examining how that theoretical discourse has been applied specifically to the automotive industry. It did this by looking at the evolution of the automotive industry, from the genesis of mass produced vehicles, through to the contemporary industry. It started off by examining the construction of the automotive industry's business model from the early days of mass production identifying early developments by Ford, General Motors and Budd and later developments by Toyota as the cornerstones of the modern industry's business model. Given that this thesis explores two cases, that of the mainstream volume car industry and also smaller producers, a range of business models for 'smaller firms' were also examined in section 3.5 which will be relevant to the second case study later in the thesis. Considering the theme of innovation and technological change, the chapter also looked at a range of potentially 'disruptive' business models that challenge the conventional logic of the car industry towards the end of the chapter. These 'radical' or 'disruptive' business models were examined with the view that they might potentially offer glimpse into alternative futures for ULEV introduction.

The categorisations of the 'Business Model Canvas', which was introduced in the literature review, were used as a tool for exploring modern developments.

The next chapter will examine the methodological aspects of the thesis, examining how the theory in the last two chapter will be applied to the research questions set out in Chapter One.

## Chapter 4:

### Research Methodology

#### 4.1 Introduction

In the first chapter, the need for sustainability was examined, with a critical perspective on 'What are we trying to sustain?', mirroring the many diverse conceptions of sustainability. In looking at the constraints that the system of automobility faces, it can only be concluded that present growth patterns are impossible to maintain given a context of resource scarcity and environmental limitations.

The thesis then progresses to the literature review, which gives theoretical context to understanding the mechanisms which can effect change in the industry. Firstly, the reasons for 'lock-in' as a result of path dependency were examined, and then there was focus on the specific reasons for lock-in to be an unsustainable technological trajectory within the automotive industry. Stemming from this, the overall nature of 'transitions' in technological regimes is examined, focusing on what happens at the niche level. The next section looked at what the traditional innovation and technology management literature discusses with regards to the question of new product development. What is less tangible is the process of innovation in respect to the firm's business model. An exploration of the developing field of business model theory leads to the third chapter, which discusses business models in the automotive industry. Through a review of the literature, different business models that have traditionally existed within the automotive industry have been examined; furthermore, some radically new business models for automobility have been given brief exposure by way of contrast. Given the research questions posed in the first chapter, the question remains as to how this thesis can explore the issue of business models in the UK car industry.

In this chapter, the rationale for the research methodology is set out, exploring issues of epistemology and revisiting the ontological issues surrounding business models covered in the literature evaluation. This covers the research methods used in this study, the evolution of the researchers' expectations over conducting the course of the study and the justifications for the use of case-study methods in presenting the findings gained from a qualitative analysis of semi-structured interview data.

## 4.2 Extent of the Research

The Introduction to this thesis sets out the reasons for the UK focus of this study (1.2.2 Focus of this thesis p.42). It also provides a justification of the focus on ULEVs (1.1.1.2 What do we seek to sustain? p.5), noting that, whilst this is a ‘soft’ sustainability response, there are compelling social and political reasons for the continued existence of personal mobility. In the introduction, the reasons for seeking more sustainable solutions within the envelope of the car and personal mobility were established. In line with the research aims, this study is not a detailed technical evaluation of different product offerings, (1.2.3 Limitations and Boundaries of this Study p.42), although there are qualitative comparisons of different technologies (considering technologies qualitatively in terms of their *environmental* **VALUE PROPOSITION**). Furthermore, there is not a quantitative appraisal of the relative volume of emissions or energy efficiency of any one vehicle design or technology. This remains a rich vein for future research and is discussed in more detail on p. 438.

In the previous chapters, the need to identify some of the structural features of the business models examined has been highlighted. Furthermore, it has been established that there are differences between the business models that SME and TNC/MNC VMs are utilising to bring new ULEVs to the marketplace. This thesis does not set out to thoroughly appraise the commercial viability of any of the business models presented, as (Timmers, 1998) highlights “*The commercial viability of any business model is a different matter altogether*”. Correspondingly, there is a limit to what participants are prepared to make available in the public domain. It is a feature of the methodology that, in seeking transparency and rejecting anonymisation as meaningless in this context, there will be some types of data that are challenging to elicit. At a time of such rapid innovation and change in the industry, it is unsurprising that manufacturers are understandably hesitant about revealing their relative positions to the public domain. As a result, the research design precludes the collection of certain types of data and this in turn shapes the ‘extent’ of the research possible.

This section makes the methodological foundations of the thesis explicit. By doing so, some of the methodological factors which define and constrain the extent of this work are highlighted.



### 4.3 Epistemology

This thesis adopts a *critical realist* perspective to the research problem. As Bhaskar (1989, p. 2) intones ‘we will only be able to understand – and so change the social world if we identify the structures at work that generate those events and discourses [...] these structures are not spontaneously apparent in the observable pattern of events; they can only be identified through the practical and theoretical work of the social sciences’.

The scholarship of engagement, discussed later on p.192, is what Barker (2004, p. 125) sees as a reaction to positivism’s focus on “value neutrality and objectiveness, rather than effectiveness”. Barker (2004, p. 125) notes that, in pursuing these aims, unintendedly the positivist epistemological standpoint puts distance between scholars and the communities they are interested in, rather than the scholarship of engagement which brings the two together in shared mutual cause. Barker (2004, p. 133) cites the endorsements of philosophers Dewey (1958; 1992) and Kuhn (1978), as endorsing an epistemological approach that is problem-driven: “driven by the subject of inquiry rather than some universal a priori standard”. Also, Van de Ven (2007, p. 14) notes that ‘critical realism’ is the epistemological standpoint that he adopts for engaged scholarship investigations. Van de Ven expands upon what this epistemology means for engaged scholarship, making the following points:

- *There is a real world out there but our attempts to understand it are severely limited and can only be approximated.*
- *All facts, observations and data are theory-laden and embedded in language.*
- *Most phenomena in the social world are too rich to be understood by a single person or perspective.*
- *Consequently, any given theoretical model is a partial representation of a complex phenomenon that reflects the perspective of the model builder.*

Simons (2009, p. 18) describes case-study research as “within the complex nexus of political, methodological and epistemological convictions that constitute the field of evaluation”. As a research method, it is epistemologically agnostic and has been deployed by both positivists and interpretativsts alike.

## 4.4 Ontology

In this study, there are two frameworks that are used as the foundation for interpreting the case studies. The transitions framework is used to interpret the macro level changes at the level of the national innovation system, whilst the business model framework is used to interpret the logic of the firm. Underpinning these two models is a discussion of the ontological foundations of the theory base.

### 4.4.1 Business Model Ontology

Some of this section restates themes that have already been considered in the literature review, so see also p.90 onwards. However, this section reviews those elements specific to ontology, that have implications for the conduct of the practical empirical research.

Osterwalder (2004, p. 42) differentiates between ‘Ontology’ (with a capital “O”), which is the philosophical discipline considering the nature and the organisation of reality, and contrasts this with ‘ontology’ (with a small ‘o’), which is used to denote the ‘explicit specification of a conceptualization’, as defined by Gruber (1993). Osterwalder (2004, p. 42) points towards an operational definition of ontology used by Uschold & Gruniger (1996), which was taken from an electronic mailing list, SRKB (Shared Re-usable Knowledge Bases). It is reprinted here in its entirety as it is seen as a significant in shaping the perspectives of Osterwalder (2004, p. 42) in formulating the ‘Business Model Ontology’:

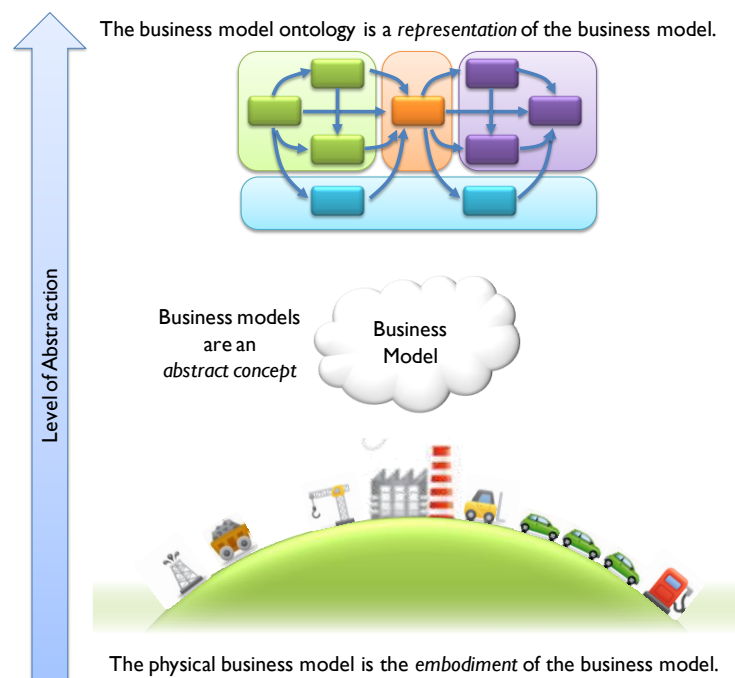
***Ontologies are agreements about shared conceptualizations. Shared conceptualizations include conceptual frameworks for modelling domain knowledge; content-specific protocols for communication among inter-operating agents; and agreements about the representation of particular domain theories. In the knowledge sharing context, ontologies are specified in the form of definitions of representational vocabulary. A very simple case would be a type hierarchy, specifying classes and their subsumption relationships. Relational database schemata also serve as ontologies by specifying the relations that can exist in some shared database and the integrity constraints that must hold for them.***

---

Uschold & Gruniger (1996) cited in Osterwalder (2004, p. 42)

This theme has been more recently approached by Baden-Fuller & Morgan (2010, p. 156), who note a long tradition in the philosophy of both science and economics of using models to provide a means of classification, a basis for investigation and ‘recipes’ for creative problem solving.

The 'business model ontology' is positioned as a framework which can be shared between firms, other professionals and academicians, providing a common basis on which to discuss business models. Baden-Fuller & Morgan (2010, p. 157) note that business model description can be used to provide a taxonomic classification of 'ideal types' of businesses, and that the community identifies certain types of business models by the names of the firms that they are most commonly associated with. The literature on business models provides many different *ontologies* of the business model (examined in the literature review); Osterwalder's (2004) being just one representation of the 'abstract concept' of the business model, and the one that is used in this research. This is illustrated below in Figure 57.



**Figure 57 - Relating the Business Model Ontology to the Physical Business**

Baden-Fuller & Morgan (2010, p. 157) note that another characteristic of models is that they are a 'scale' version of the real thing. An Air-Fix model of a Jaguar cannot fail to capture the intricacies of its mechanics and engineering but it does give a generalised abstract impression of the car's shape and form, and from this generalisation it can be identified. Similarly, business models cannot begin to capture the whole complexity of an enterprise but can give a *scale* impression of its general characteristics.

Baden-Fuller & Morgan (2010, p.159) cast *'theories of firm behaviour'* and *'the real world of firms'* as opposite ends of a scale, where theory represents a very generalised non-specific view of behaviour and the real firm is rich in specific fine grained detail. The business model, however, sits in this liminal space, where it captures a degree of specificity, albeit in a form that captures *salient features* in limited detail. Why is this useful? The analogy is drawn between business models and biology, where taxonomic classification of creatures allows for *"the successful characterization of similarity and the definition of difference"*. Furthermore, Baden-Fuller & Morgan (2010, p.161), through considering the foundations of science, draw a distinction between business model taxonomies and typologies, with the former being a classification of things that have been observed in the world and the latter drawing upon more Weberian notions of constructing abstract *'ideal types'* to which real world phenomena are fitted. The methodology in this thesis leans towards an examination of those firms that can be *observed* operating in the UK, and the empirical analysis is constructed from these observations and therefore leans towards the latter. However, the segregation of these embedded cases into the two constituent cases speaks more to Weber's typologies; however, in this case Weber might have considered the extant regime a *'non-ideal type'*!

#### **4.4.2 Transitions Ontology**

Similarly, transitions theory gives a framework through which the nature of socio-technological transitions can be interpreted and understood. Geels (2010, p. 495), in response to the criticisms of transition theory, considered the theory against seven social science ontologies, with a view to positioning transitions in relation to these theories. Geels (2010, p. 504) evaluates 'Rational Choice', 'Evolution', 'Structuralism', 'Interpretivism / constructivism', 'Functionalism (systems theory)', 'Conflict & Power Struggle' and 'Relationalism' in relation to transitions theory. Geels (2010, p. 495) positions transitions theory, not so much as a 'grand unifying theory', but as a 'middle range theory' [expanded on p.62] (Merton, 1968). In a similar vein to the business model ontology, this starts with an observation in the physical and social world, and then proceeds to abstract from this reality to form a model which through collected data can be seen to be helpful. Here, much of the conversation in the preceding section about "models" is equally applicable to modelling transitions using this structure.

## 4.5 Literature Analysis Methodology

The candidature of this thesis took place over an extended period. This has shaped the literature review, which has been concurrently evolving alongside the research. A great deal of new scholarship generated on both business models and transitions has necessitated constant revisions and updates.

In addition to the traditional 'manual' literature review, the search of the business models literature was augmented by a Citation Network Analysis, which is summarised in Appendix 2. This was conducted at the start of the research process in order to provide the researcher with an understanding of the significance of articles within the literature. This was helpful in unpicking the connections between various pieces of literature in the early stages of this study. This approach is both novel and methodologically interesting. However, the software used was experimental. At the time, there were vulnerabilities in the system Google Scholar used to protect its database from being accessed by external programs. This shortcoming was in time addressed by Google rendering the software defunct and, it was for this reason, the approach was not consistently applied in later iterations of the literature review although it is noted for its methodological interest. This is the explanation for it being included as evidence of methodological innovation, rather than as part of the core work. Whilst the CNA process might identify literature, it provides no analysis of the 'content' of the literature. It is useful, but only to a certain point. It was important to also identify significant literature reviews that synthesised the findings of multiple research papers. Furthermore, particular attention was given to edited books, which 'drew together' contributions from multiple experts in a field. In addition to this, attention was also given to journal special issues, which acted as a 'focal point' for significant developments in the field.

This research charts a story which is fast moving; a great deal of manufacturers' 'grey literature' has been collected from conferences. Furthermore ephemera and online news and analysis has been used to provide up-to-date information. Whilst not peer-reviewed, the cycle of peer review means that real-world events may take significant time to make it into journals and the academic community.

## 4.6 The Case Study Method

The case study method provides an organising framework for the empirical data. The following process chart in Figure 58 gives a description of the case study process that is being followed.

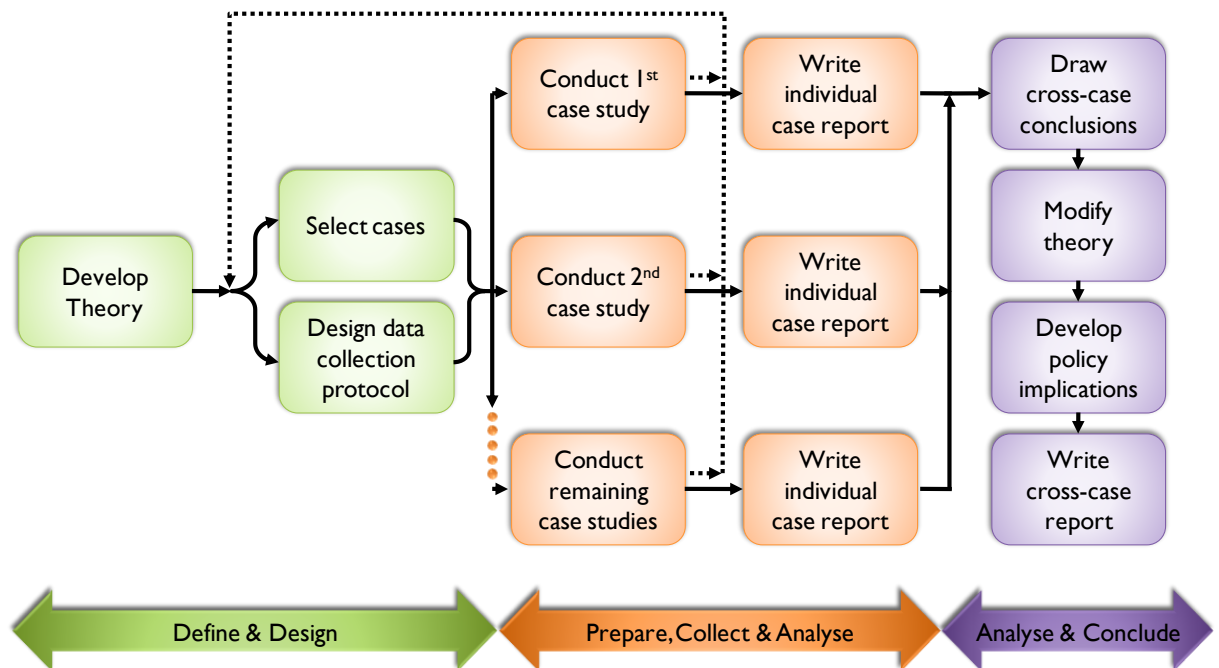


Figure 58 - Case Study Method: Redrawn from (Yin, 2009), Source COSMOS Corporation

The theoretical base for the research was defined in the literature review and the subsequent chapter on the car industry. It was this third chapter that formed the basis for the selection of cases: the 'TNC/MNC' vehicle producers that form the 'traditional' car industry and smaller 'SME' producers which share the characteristics of being small, 'niche' and potentially insurgent. Alongside the case design (reviewed in the next section), the Data Gathering Methodology was designed, which will be reviewed on p.192. The next section discusses the structure of the case studies, and how 'embedded case studies' of individual firms are taken as components of larger over-arching industry case studies helps to resolve tensions about 'units of analysis'. Within each case, there is an embedded analysis. The two cases, (p.257 and p.304 respectively) are then considered in the conclusions to this thesis which result in the outcomes of theory, development and analysis. There are also some suggested policy directions, as this resonates with both Yin's (2009) case study methodology and the practical approach to 'engaged scholarship' that has been adopted by this thesis (Discussed further on p.192).

#### 4.6.1 Structuring the Case Study Design

Yin (2009, pp. 31-32) discusses a variety of different case study designs and structure and notes the importance of correct case study structure selection for the examination of different phenomena. Looking in terms of case structure, the case-study method views each case-study as embedded within a 'context'. By way of parallel, the transitions framework paints niche-innovations as forming part of a challenge to regimes and this niche-regime interaction exists against the backdrop of a 'landscape' [this is examined from p.53]. The context in which the cases are rooted is considered within the scope of Chapter 5 and provides a UK-specific analysis. Broader global issues were also considered in the preceding chapter.

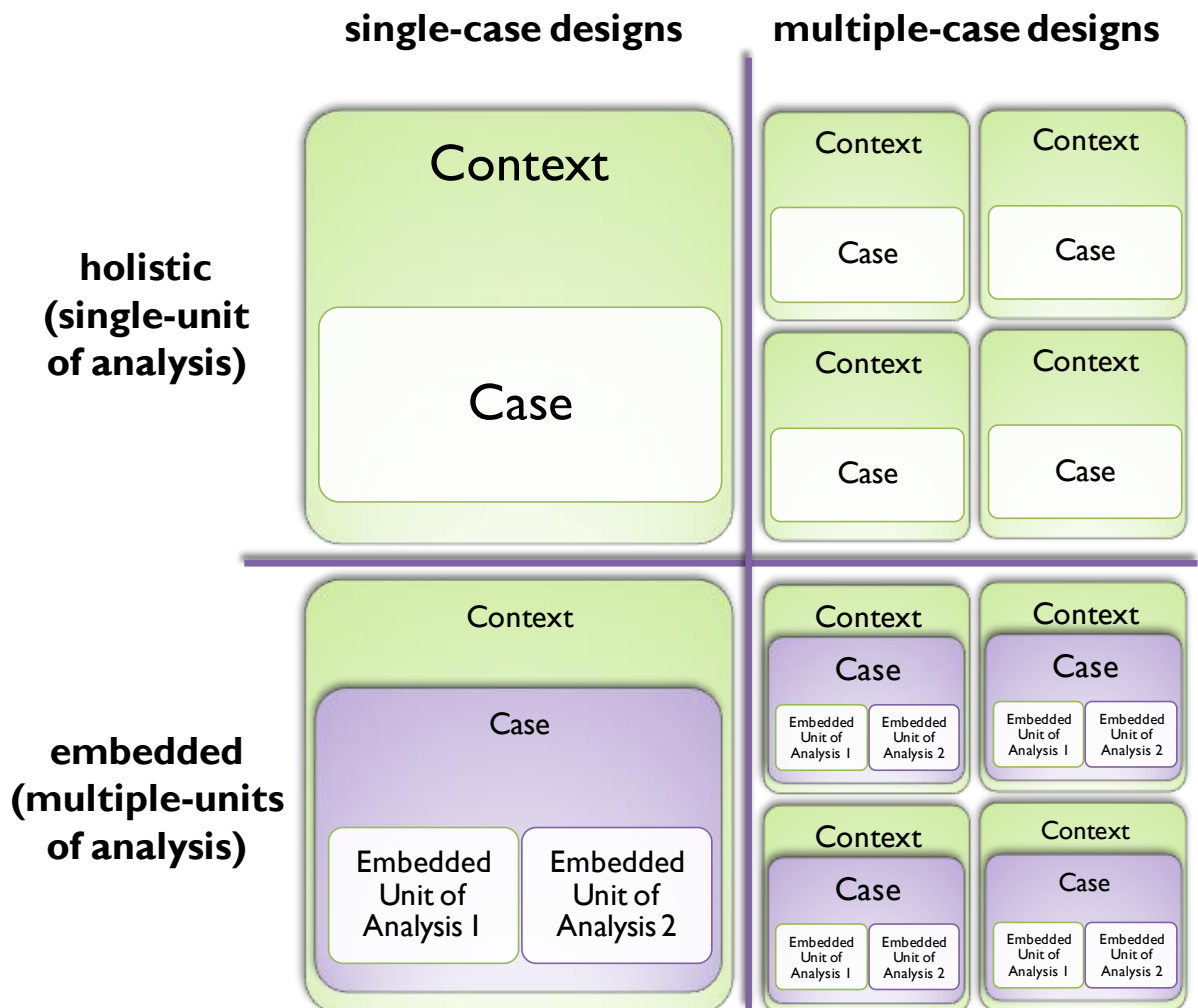
Yin (2009, pp. 31-32) urges careful consideration of the '*unit of analysis*'. Through illustration with a number of cases, Yin (2009) makes the point that a researcher may believe they are examining a certain thing or aspect of interest, however, it is important to position the case in relation to the broader body of knowledge that the case seeks to advance.

In the context of this study, whilst the empirical data collected provides an evaluation of individual firm's business models, it is not the 'business model' itself which comprises the 'case' but the totality of firms working within the industry to achieve transition. Here, there is a dual perspective as each individual firm provides a snapshot of a firm working within part of a wider transition. There is interest in the individual firms and the actions and trajectory of '*niche actors*' involved in the process of transition; whilst these form embedded cases, the main topic of examination is not the dynamics of the individual firm but the overall process of transition.

Accordingly, with the emphasis on the *sum total* of the embedded cases rather than on each individual case, there is room within the research method to accommodate some variation in the quality of individual embedded cases. Section 4.7.3 Population Definition (p.196) accounts for the practical challenges of data collection, the problems of gaining access and the respondents' different attitudes towards the research which all leads to a variable quality of data. This is reflected in the embedded

cases. This would have been challenging were the unit of enquiry the firm's business model, however, as the embedded cases provide facets of a larger case, there is some degree of redundancy.

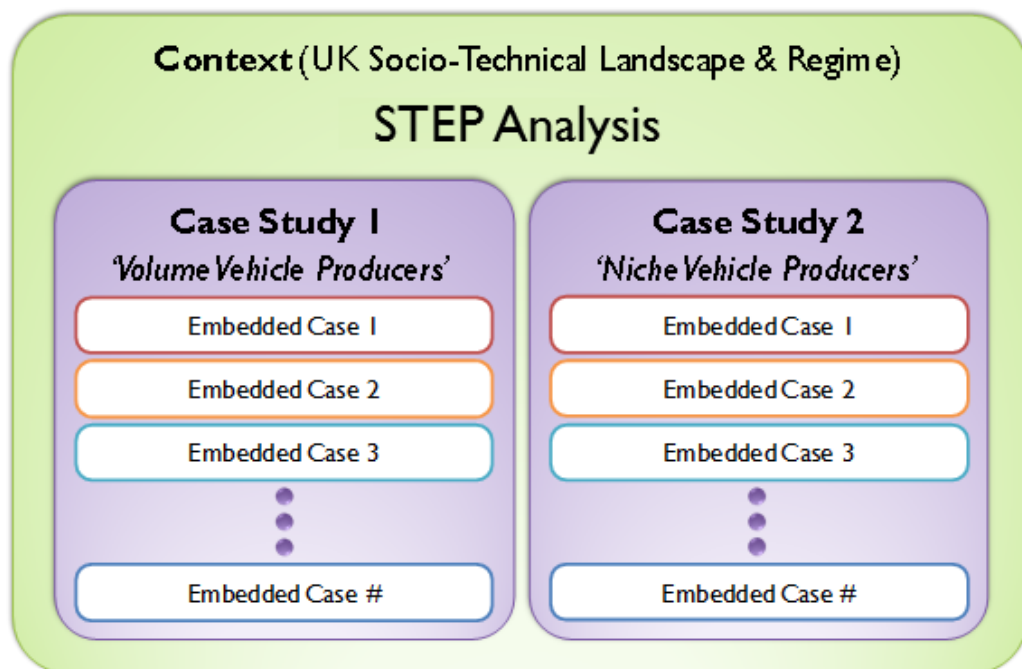
Figure 59 (below) presents a typology of different generic case study designs. These are sorted firstly, by the unit of analysis, single or multiple, and secondarily by whether the studies address single or multiple case designs. Yin (2009, p. 53) however considers "both single- and multiple- case designs to be variants within the same methodological framework" and does not draw a distinction between 'classical' single case studies and multiple case research.



**Figure 59 - Basic Types of Designs for Case Studies :**  
Redrawn from Yin (2009, p. 46) Source: COSMOS Corporation



One of the approaches, that Yin (2009, p.59) advances is to conduct a “two tail” case design. This is where cases (or embedded cases) from two ends of an extreme, or ‘an important theoretical condition’ are selected [resonating with McKelvey’s (2006) calls for a focus on the extremes]. This then forms the basis for a cross case comparison. In this study, there are two “Cases” that are of the established volume vehicle industry; the ubiquitous marques that consumers are familiar with, the smaller TNC/MNC VMs and those of smaller and sometimes less familiar firms (The SME VMs). However, these examples are comprised of multiple embedded cases. Yin (2009, p. 53), speaking about the work of Herriot & Firestone (1983), says that “the evidence from multiple cases is often considered more compelling, and the overall study is therefore regarded as being more robust”. This leads to the case study design depicted below in Figure 60; two cases embedded in a common context, with each case comprised of multiple embedded cases. The next section evaluates the construction of the embedded cases.



**Figure 60 - Case Study Research Design for this Study**

It is observed that there is a great degree of homogeneity between the embedded case studies of TNC/MNC car producers (the *institutional isomorphism* of which Wells & Nieuwenhuis (2012) speak). The large scale of vehicle production, by the nature of the processes used, dictates and constrains

certain elements of the business model. Nevertheless, there is still sufficient variation between the different strategies chosen by TNC/MNC VMs to allow some interesting observations to be made about the way that vehicles are being introduced to the UK marketplace.

The second case study comprises of an examination of SME VMs in the UK that are looking at introducing ULEVs to the UK marketplace. There is a lot more variation between these companies. They are, almost by their nature, much smaller, and similarly the processes and technologies employed for vehicle production shape the nature of these companies' business models.

The analysis of the case studies comprises a comparison between the two case studies, looking at what business model elements are similar in both TNC/MNC VMs and small scale VMs. Moreover, the differences between TNC/MNC VMs and SME VMs provide a richer vein of exploration. The challenges of reconciling the difference of scale provides some challenges (Considered later p.198).

#### **4.6.2 Constructing the Sub-Case Studies**

Magretta (2002) defines business models as “*stories that explain how enterprises work*”. Each embedded case is a story of an enterprise engaged in the process of bringing ULEVs to market. In formulating the case studies of the firms examined, the researcher has tried to treat the examination of those firms' business models, not as isolated snapshots of the present status quo, but as scenes in a longer narrative. The view of individual firms has sometimes been extended to chronicle the antecedents and combination of circumstances, people and their experiences that resulted in the formation of the new ventures under examination where this is seen as relevant.

In particular, when constructing the case study accounts of the different entities examined, due care has been given to ‘*preserving chronological flow where it is important*’ (Miles, 1979), as, in many cases, understanding the pathways of the business model's evolution can help with understanding the process of Transition. Yin (2009, p. 53) notes that “*A major insight is to consider multiple cases as one would consider multiple experiments – that is to follow a ‘replication’ design.*” In this study, there is a degree of

replication using the 'Business Model Canvas' as a tool to structure thinking, and using a consistent approach to each enterprise. Some devices, such as timelines, also appear in multiple embedded cases.

As already noted on p.187, there is significant variation in the length of the case studies. This in part was dictated by the depth and richness of information available and the complexity of the stories which needed to be articulated. As Baden-Fuller & Morgan (2012) note, these cases are only *models*. Some of the SME VMs especially by nature of their small volume employed business models the core of which could be explained in a relatively straightforward manner. With some of the embedded cases in the volume industry, there is no need to restate those elements of the business model that are "generic" or widely understood; the foundations of the automotive industry business model are already well accounted for in Chapter 3 (p.124). However, the cases that require more detailed explanations are where the firm's business model diverges from the ordinary. In some cases, these may not even be successful businesses; however the stated research aims are not to appraise viability but to search for novel thinking and innovation. Returning to Baden-Fuller & Morgan's (2012) conceptualisation of the business model concept as "scale independent", capturing the business logic of a small firm in the same detail as a large one can often provide interesting juxtapositions, which can sometimes prove to be a distortion. Returning to the 'Air-Fix' analogy, some of these embedded case models are 'dinghies' but the models are built to the same size as 'aircraft carriers'.

## 4.7 Data Gathering Methodology

This section reviews the practical details concerned with the collection of qualitative data. The section opens with an exploration of Research Ethics in relation to this study. The ethical considerations surrounding this research supported the selection of an 'Engaged Scholarship' perspective to the study, with manifold ramifications for the conduct of the study.

### 4.7.1 Research Ethics

The 'UK ULEV Community of Practice (Lave & Wenger, 1991; Wenger, 1998; Wenger, McDermott, & Snyder, 2002)' is a small and tightly integrated community. Anonymity is meaningful where there are large groups of potential respondents; however, there are a limited number of potential firms to approach. In trying to garner a complete picture, an attempt has been made to be as comprehensive as possible and sample as many firms from the small group that is available. The informal knowledge flows between members of this community appeared to negate any notion that 'anonymity' would be in any way either meaningful or useful. Anyone operating in the industry with reasonable knowledge would be able to identify anonymised companies through the detail of the case studies. Rejecting anonymity as neither relevant nor helpful, it was decided to proceed on the basis of an open discussion between professionals engaged in the same area. This approach was defended in a submission to Cardiff Business School Research Ethics Board. (The documents for which are in Appendix 5 p. 513).

### 4.7.2 Engaged Scholarship

The research approaches the questions posed from the perspective of "engaged scholarship". It is helpful to start with a definition;

***“Engaged scholarship represents a strategy for surpassing the dual hurdles of relevance and rigor in the conduct of fundamental research on complex problems in the world. By exploiting differences in the kinds of knowledge that scholars and practitioners from diverse backgrounds can bring forth on a problem, engaged scholarship produces knowledge that is more penetrating and insightful than when scholars or practitioners work on the problem alone.”***

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(Van de Ven, 2007)

Van de Ven (2007) highlights that the outputs of engaged scholarship should be formulated in such a way so that they speak to both the domains of practice that have an interest in the research and also to the academic disciplines in which the research is rooted. Van de Ven (2007, p. xi) argues that engaged scholarship research can have a much greater impact than that conducted by scholars or practitioners alone in isolation. Engaged scholarship brings the multiple views from other stakeholders together in a piece of research (Van de Ven, 2007, p. 10). In this respect, through a dialogue with practitioners in the automotive industry, this approach to the research aims to bring together knowledge gained from practice with possible explanations drawn from theory in the literature.

***"Engaged scholars recognize that community-based scholarship is founded on an underpinning of mutual respect and recognition that community knowledge is valid and that sustainability is an integral part of the partnership agenda."***

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**(Fitzgerald, Burack, & Seifer, 2010)**

Engaged scholarship can also surmount some of the ethical hurdles of traditional research by recognising the mutual respect between academics and practitioners within the community who can contribute to the research; in other words it is investigating *with* rather than *into* a community of practice. With an emphasis on shared respect between members of the community and community knowledge sharing, the conversation adopts a collaborative tone in contrast to more *combative* (Franco, 2006, p. 814) forms of research enquiry.

Martin (2010, pp. 214-217) suggests a spectrum of five different levels of practitioner 'engagement' with scholarship. At this stage of the research, it is clear that the research design engages with (1) 'Practitioners as informants' and it is certainly possible to articulate a desire to engage with (2) 'Practitioners as recipients' post publication. However, to some degree the level of engagement is constrained by the requirements of a 'Doctoral Thesis'. Other potential avenues for engagement are (3) Practitioners as endorsers, (4) Practitioners as research commissioners, (5) Practitioners as co-researchers. This, however, does not fit well within the specification of the doctoral thesis and so must be discounted for this work. That said, Martin (2010, p. 218) emphasises the benefits of 'engaged

scholarship' when adopted for 'the long haul', and so perhaps the other levels of engagement outlined in the article provides a template for future work.

So, how is engaged scholarship applied in action? Revisiting the introductory chapter and the concept of 'backcasting' (See p.8), as with many methods for examining sustainable futures, 'engaged scholarship' requires professional communities to evaluate alternatives to the status quo.

***“A basic proposition of the engaged scholarship model is to compare and contrast a proposed model with plausible alternative models.”***

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**(Van de Ven, 2007, p. 30)**

A theme that was mentioned in the introduction (p.8) is that the formulation of strategy for sustainability concerns itself with not only in studying 'what is' or 'what has been', but more importantly applying some near-term foresight to the problem to try and establish “what could be”. These future possibilities gain credence through their construction in collaboration with the community charged with implementing them. In this respect, the comparison between the proposed 'industry accepted' model as furthered by 'the traditional industry' and TNC/MNC VMs is extended by glimpses of alternative future realities embodied within SME niche actors; in other words examining some of the innovative responses of the established industry and also looking to smaller, 'insurgent' firms, which have the potential to grow their market share and/or act as incubators for new ideas, processes, designs and business models. The next section addresses the definition of 'incumbents and insurgents'. This process contributes to the study's stated aim of giving insight into potential future 'change models' for businesses trying to introduce ULEVs to the marketplace. Welch (2009) suggests the spirit of engaged scholarship is to ask the question: 'What would it mean if we didn't do this work?'. Academically, this thesis identifies the shortcomings in the literature on p.115 of the review. The researcher believes these gaps are important to address. In practical terms, however, what does this work mean for practitioners and what would be the consequences of its absence? Assessing the impact of work *ex ante* is challenging and problematic (Donovan, 2011). However, there is perhaps a different way of approaching the above assertion, reframing it as: “How can we make the research relevant to practitioners, and disseminate it in such a way that it makes a useful contribution to the communities

of practice with which it engages?” Presenting these findings in a way that is useful to the community of practice provides additional validation for the selected research methods, as (Simons, 2009, p. 18) relates the usefulness of case-studies to practitioners:

***“Case study reports that are issue-focused, comprised of naturalistic observations, interview data and written in the language of participants allow access to findings that others can recognise and use as a basis for informed action”.***

---

(Simons, 2009, p. 18)

Another approach to this question can be found in Wells (2013, p. 140) who discusses the social construction of time in relation to the temporal dimension of sustainability. He notes that our relationship with time is not ‘value-free’ and that the “*language and discourse of crisis is suggestive of time running out*”; given the frame of Wells’ (2013) work ‘Business Models for Sustainability’, he (2013, p. 140) suggests “*This makes the search for mechanisms of transition all the more important and innovations in business models may be such a mechanism*”.

#### **4.7.2.1 Criticisms of Engaged Scholarship**

This is not to say that the notion of ‘Engaged Scholarship’ is an entirely uncontroversial methodological paradigm. In a lively series of exchanges, Van de Ven & Johnson (2006), have defended their approach against criticism from McKelvey (2006, p. 822) that “*bias and disciplines and particularism still remain*” despite Engaged Scholarship’s attempt at methodological innovation. McKelvey’s contention is that the main barrier to the advancement of management science cannot be solved through engagement as this leads to the researcher studying ‘average’ phenomena that firms are willing to disclose. Contesting that (McKelvey, 2006, p. 828) Van de Ven & Johnson (2006) restate their case in the face of criticism that ‘engaged scholarship’ does not aim to further practice at the expense of theory.

Even the critics of ‘engaged scholarship’ such as McKelvey (2006, p. 823) can at least share in understanding some of the frustrations that ‘*business school research is increasingly held hostage to the epistemology of basic disciplines*’; however, McKelvey (2006, p. 823) also cautions against the opposite extreme i.e. making research hostage to practitioners perspectives.

### **4.7.3 Population Definition**

In seeking to answer the research question thoroughly, it was important to capture a sufficiently comprehensive cross section of the business models employed in the UK ULEV Industry as was possible given constraints and practicalities. To this end, the thesis characterises the ‘extremes’ of the industry [partly as a response to the criticisms levelled at engaged scholarship by McKelvey (2006)]. In doing so, the ‘traditional’ car industry is characterised as providing the most visible responses to the introduction of ULEVs. However, in the search for extremes, the ‘hurricane science’ that McKelvey (2006) seeks, SME vehicle manufacturers provide a counterpoint case study. Here there are two distinctly different leitmotifs that run through both of these cases; the TNC/MNC manufacturers being to a large degree *institutionally isomorphic* (Wells & Nieuwenhuis, 2012) and, in the main, wedded to processes such as pressed steel that require production scale, whilst SME vehicle manufacturers use an array of more labour intensive but flexible processes which result in lighter weight vehicles.

#### **4.7.3.1 Criteria for Selection**

The criteria for selection is whether firms were or were planning to manufacture ULEVs, and also had a UK manufacturing presence that could potentially be engaged in this process. Actual vehicle production in the UK was not a prerequisite, as long as intent could be shown to do so. In this definition, firms were included that, whilst they were manufacturing vehicles in the UK, were not currently manufacturing ULEVs in the UK; however, as it could be expected that at the end of current model production plans, with reasonable foresight, this capacity could be used in the future for the purposes of manufacturing ULEVs. Furthermore, amongst the TNC/MNC cases, there are firms that without clearly articulating plans for future UK models have exhibited prototype vehicles to gauge consumer interest showing a clear intent to engage with this arena in the future.

#### **4.7.3.2 Degree of UK-based activity**

The study restricts itself to those organisations where a significant proportion of the design and/or research and development activity and manufacture of vehicles occurs within the UK. This therefore excludes those who are solely “importers” of complete vehicles which are ready for sale or whose



operation in the UK comprises a retail operation only. In the SME case studies, there are companies importing vehicles designed for other markets, modifying them for UK use or modifying complete vehicles.

#### 4.7.3.3 Size of Firm

The firms engaged in manufacturing ULEVs who are discussed in this thesis, have manufacturing operations that are on radically different scales. The following scaled satellite images of the factories of some different UK firms engaged in manufacturing ULEVs illustrates this.

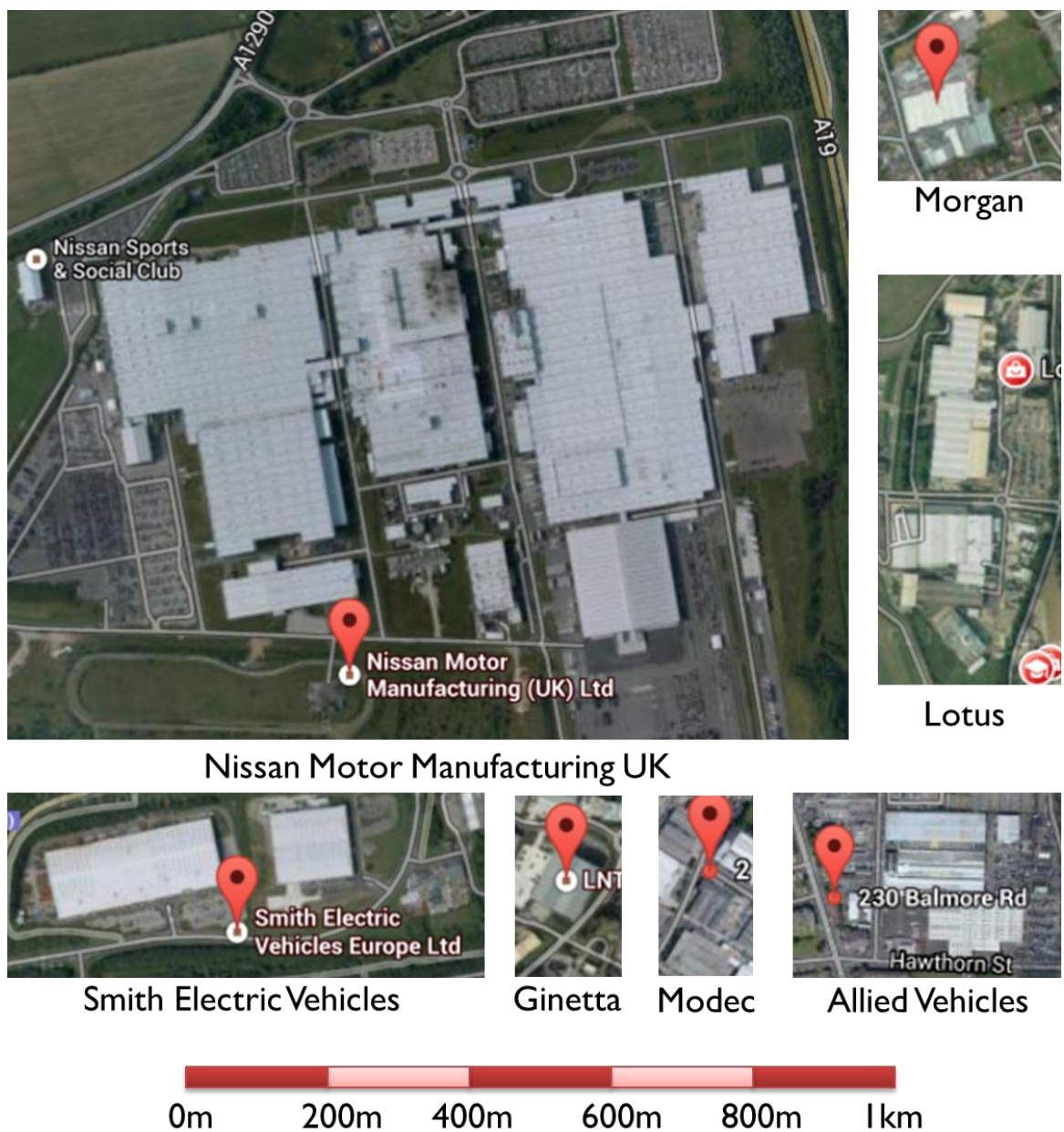
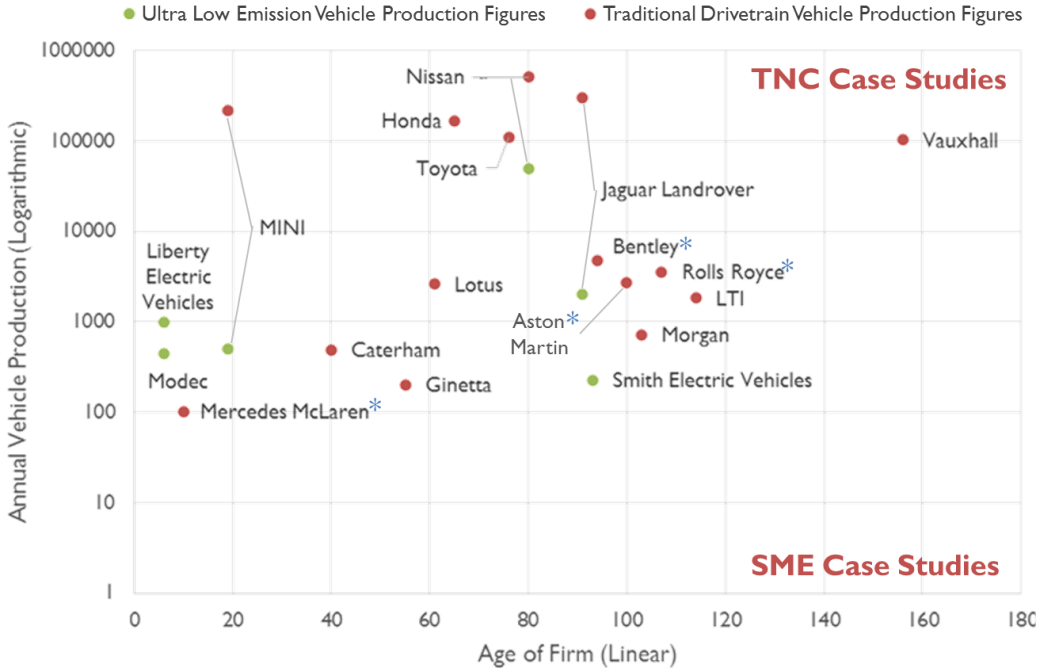


Figure 61 - ULEV Manufacturing on Different Scales

One of the challenges posed in defining the populations of the two cases under examination is how to delineate between the embedded cases that comprise the two cases. What constitutes the ‘traditional’ industry, and who can be classified as the ‘insurgents’? In other words, who is part of the dominant regime, and who is not? The problem of definition is a challenging one. Take the example of Smith Electric Vehicles, Morgan or LTI. These are long established firms but are still small in scale. In the end, the decision was taken to delineate between the two cases based on scale of production.

There are a few cases for which the decision as to what case to assign them to is problematic. Mercedes McLaren, Rolls Royce and Bentley are linked to much larger automotive concerns. Aston Martin, having formerly been part of Ford’s Premier Automotive Group, but now without the influence of the larger company, could be considered a smaller firm, however, there are discussions about platform sharing with Mercedes. The decision has been taken to allocate these to the TNC/MNC Case Studies, as, whilst these companies’ production figures are intermediate in scale, they benefit from a corporate hinterland of much larger firms’ support, sourcing and supply chains. Ultimately, there is some degree of subjectivity in this decision, of allocating embedded cases to sets. It could have been argued to have ‘three’ Case Studies, differentiating very small manufacturers, mass market volume producers and an intermediate level of premium brands producing vehicles at an intermediate volume. That said, it was felt that a simpler, two case study design would yield clearer contrasts.



\*These firms are hard to classify, as whilst their production figures are low, they have the support of much larger automotive firms behind them; Mercedes in the case of Mercedes McLaren, VW in the case of Bentley, BMW in the case of Rolls Royce and previously Ford in the case of Aston Martin.

**Figure 62 - Age of Firm vs. Annual Vehicle Production: A Profile**  
**Estimated annual production figures compiled from a range of sources, including SMMT.**

#### 4.7.4 Sampling Frame

The sampling frame aimed to capture at least one response from an individual ‘qualified’ to answer on behalf of the organisation they represented. In practice, this was found to be challenging and ambitious. Whilst there was some degree of success in reaching senior management at larger firms, this was not universally possible. Secondary data was used to provide support across all of the case studies and, in some cases where access proved impossible, the cases are reliant on secondary data.

It perhaps is worth revisiting the case study structure here to reaffirm the ‘unit of enquiry’. Our two case studies are the ‘traditional high volume motor industry’ vs. ‘smaller firms producing at lower volumes’, but potentially with the ability to disrupt the industry. As such, it is the robustness of the ‘whole case studies’ that is of interest, with that of the embedded cases being of secondary concern. As the ‘transition’ is under examination, there is room for some redundancy in the embedded cases.

Whilst the sample aimed to be comprehensive in the scope of the organisations covered, within those organisations the interviewees were selected on the basis of convenience sampling initially. The interview structure contains elements of ‘*snowball sampling*’, in that at the end of the interview, participants were asked for direction on whom to speak to next. Atkinson & Flint (2001, p. 1) note that, whilst the snowball sampling defies many of the traditional sampling criteria, such as being random, it does lead to better identification of experts in a field. A true snowball sample would require every lead to be followed; however, the method here used would be closer to “*expert respondent identification*” with the researcher applying a filter to results based on who was deemed relevant to the study.

#### 4.7.5 Issues of Access

The challenges of securing access to elites are well documented in the social science literature (Atkinson & Flint, 2001; Odendahl & Shaw, 2002; Desmond, 2004). In the case of the smaller firms interviewed, it was often not a problem to secure access to the CEO or Founder of the firm. However, with the larger organisations sampled, issues of access were challenging.

When access was gained, respondents were often conservative about 'speaking for the firm'. Incumbent firms have brands to defend and maintain and decision making and strategy is decentralised.

Here are some important observations that may have implications for business model theory, which have spawned from this methodological question:

- To what degree is understanding of the business model 'shared' throughout the organisation?
- To what degree does everyone within the organisation need to have oversight of the totality of the organisations business model?
- If there is a divergence of understanding of the business model at different levels of the firm, does the firm suffer for this?
- Whose responsibility is Business Model oversight and innovation?

These are all questions that arise from a simple methodological challenge in large organisations – what individuals can be accessed who have oversight of the firm's business model? In such large concerns, it is nigh on impossible for a lowly doctoral scholar to gain access to the highest echelons of management, and, as a result, the cases construct the view of the firm's business model through the eyes of others. Here, the thesis returns to the epistemological question that, whilst there may be a "reality" out there, it is only possible to approximate that reality with a model, and that model is constructed from the perspective of the model makers (p.181).

The researcher found particular value in speaking to those people who were engaged in the ULEV community of practice but were located outside of an individual firm. Whilst individuals working for certain firms had strong intra-firm networks and could refer to others within firms, identification of people from other firms was better garnered from those working in government for the now defunct regional development agencies, industry bodies, or those working on deployment of vehicles.

#### **4.7.6 Interview Technique**

As the literature review identified, there is much discord in the field about the 'definition' of a business model. The ontological position of this thesis is stated that the 'Business Model' is an abstract concept which can be viewed through the lens of various frameworks or ontologies. However, this still

presents a challenge for the researcher who cannot presuppose any knowledge of these ontologies on the part of the interviewee. This point is driven home by Linder & Cantrell (Changing Business Models: Surveying the Landscape [Working Paper], 2001, p. 2), who further this consistent theme that runs through the literature that, whilst the term 'business model' is used widely in business, its precise meaning has many interpretations within the academy, and perhaps this lack of clarity explains why it is not well understood by practitioners.

***Today, executives can't even articulate their business models. Everyone talks about business models but 99 percent have no clear framework for describing their model. They do know what business they're in—they just can't describe it clearly. And if they can't describe it clearly, they can't share it effectively throughout their organization.***

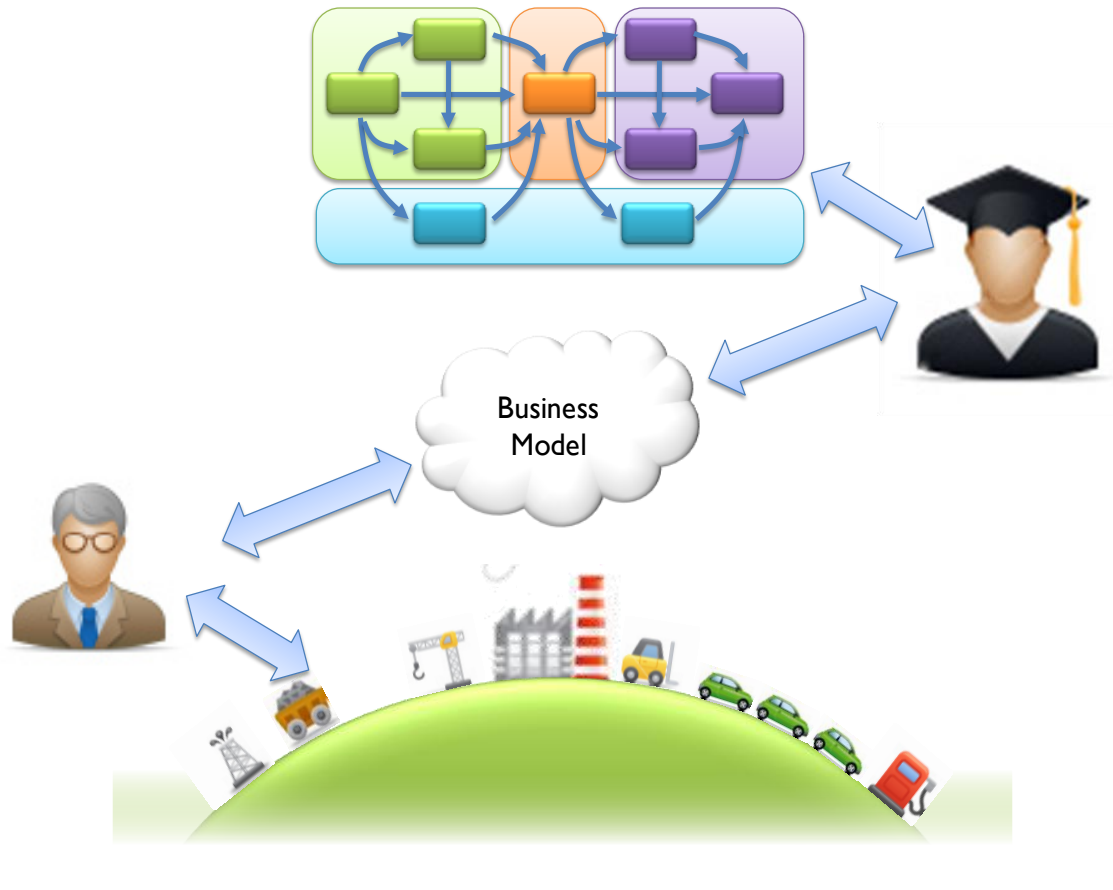
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(Linder & Cantrell, 2001, p. 2)

This presents a very real challenge for the researcher, as in order to make meaningful comparisons between the collective case studies in this research, there must be some shared ontology to allow critical comparisons to be made between different companies.

Bryman & Bell (2007) describe the challenge of '*finding a path through the thicket of prose that makes up your data*' in relation to qualitative data analysis. In order to make this prose more easily navigable, the interview technique concentrated on using the frame work of Osterwalder's 'Business Model Ontology' (2004) Ph.D thesis on business models, and his later 'co-created' book (Osterwalder & Pigneur, Business Model Generation, 2010). These were used to bring both loose structures to the interviews and to provide a means of comparison in later coding. It cannot be readily assumed that the interviewee will have a prior knowledge of Osterwalder's Business Model Ontology. Furthermore, as issues of access have been discussed, within the constrained time frame available to conduct an interview, it is not possible to build meaningful shared definitions or explore the abstract framework in depth. The Business Model Canvas has been used in workshop settings to explore and co-create an understanding of business models with professionals; however, this was not deemed possible for this study. The interview technique and design selected requires the skill of the researcher to garner meaningful data with knowledge of the Business Model Canvas from the interviewee so that it will

later be used to inform the embedded case based on the Business Model Ontology. This process is illustrated in Figure 63.



**Figure 63 - The 'business' interviewee and the 'academic' interviewer – two types of business model knowledge**

The themes and topics identified for discussion in the semi-structured interviews were identified from the account of business model elements given in Osterwalder & Pigneur (2002). The initial question pool was formulated in relation to automotive manufacturers; however, as the initial question set was designed to apply to a range of manufacturers both big and small, there was a large degree of “on-the-fly” tailoring of questions to suit the understanding of the interviewees’ organisational context. Questions were shaped in such a way that they should sound ‘authentic’ to the interviewee and be relevant to the context of previous responses by the interviewee. Appendix 4: Initial Interview Question Pool (See page 510) contains a “pool” of questions, used as prompts from which questions

were drawn in the course of the semi-structured interview. The selection of questions on the day drew on the researchers pre-existing knowledge of the interviewees and their organisation. Where answers emerged to subsequent questions in the course of the interview, these were omitted or tailored, as questions were also being guided by the responses of interviewees. The questions are divided into nine areas of the business model, with some opening 'framing' questions and concluding questions.

Whilst working from a theoretical 'structure' of business models advanced by Osterwalder & Pigneur (2002), the poorly understood nature of this field of enquiry means that much of the research will be exploratory, in other words 'excavating' data to build a framework upon which data can then be 'constructed' by semi-structured interviews with a more in-depth understanding of the phenomena under observation. In terms of the level of structure given to the interviews, whilst the semi-structured questions provided a "back stop" for the researcher, often participants were keen to highlight certain aspects and dimensions of the business model. The need to understand participants' views of the business model often took the interview in unanticipated directions. Furthermore, there were some elements of the questioning which participants were unwilling to discuss given commercial sensitivity, unfortunately this is just a limitation of the method. As Maxwell (2002) states '*Understanding is a more important concept for qualitative research than validity*', in particular due to the complex nature of the manifold business models employed by vehicle manufacturers, the many factors that affect their development and the fast-changing nature of the environment within which they operate perfect 'repeatability' is a realistic aim. Brinberg & Mc Grath (1985) also state that '*validity is not a commodity that can be purchased with techniques... Rather validity is like integrity, character, and quality, to be assessed relative to purposes and circumstances*'.

## 4.8 Analysing Interview Data

Miles (1979) describes qualitative data as ‘an attractive nuisance’, as whilst it provides a ‘rich, full, earthy, holistic “real” account it also generates a considerable quantity of data which the researcher must manage. These concerns to some degree have been addressed through the use of Computer Assisted Qualitative Data Analysis (CAQDAS). Once the interview recordings were transcribed, the data was analysed to make sense of the themes which cut across the embedded case studies.

There were a number of recordings which proved challenging to transcribe due to levels of ambient noise [where these were conducted at conferences / trade shows e.t.c.]. Furthermore, a couple of the recordings were lost due to technical problems with hard disk failure. Here, the researcher relied on extensive notes taken during the interview as the costs of data recovery were prohibitive.

The textual analysis of interview transcripts was undertaken aided by CAQDAS, using the MAX QDA 10 software. There are a number of advantages of this approach over manual methods of coding. Odena (2007) provides a thorough review of the advantages of CAQDAS; the MAX QDA software was selected on the basis of its intuitive interface and usability. (Kuckartz & Kuckartz, 2001). The case study data was sorted into two ‘sets’: ‘TNC/MNC vehicle manufacturers’ and ‘SME vehicle manufacturers’. The following coding system was then used to code the themes in the data.

The software offers a wide range of analytical tools that are appropriate for different applications; however, in this instance, the basic functionality of the software was employed to categorise, sort and navigate the data according to the themes identified in the coding system. This is set out in the next section, and there is an example of a coded segment of data in the screenshot in Appendix 6.

### 4.8.1 Coding System

In devising a coding system, it had to be taken into account that, whilst the study focused in the main on finding respondents who could provide details about the ‘embedded cases’ i.e. the firms introducing ULEVs to the marketplace, there was also a significant input of expertise from commentators and others involved in the ULEV community of practice. Thus sufficient allowance had to be made in the



coding scheme to accommodate these views. In the main, these were accommodated under the headings of 'Innovation' and the Transitions headings of 'Landscape, Regime and Niche'. These were then used to supplement the cases by informing the context.

In this description that follows, where colours have been allocated to coded themes, the convention used has been to include the name of the code in squared brackets, followed by a swatch of the colour coded. E.g./ [Code ■]

The interview data was sorted and coded into a series of themes. Parts of the narrative which related to '**key dates**' in the company's history were used to construct the background to each embedded case study; this was coded as [Timeline (Dates) ■]. Any data relating specifically to '**innovation**' or the way that innovation was managed was coded as [Innovation ■]. When interviewees explicitly referred to the relative sustainability of their product offering compared to others in the marketplace or discussed issues of '**sustainability**', this was coded as [Sustainability 'performance' ■]

Elements of the business model were then coded using a structure whose hierarchy reflects the structure of Osterwalder and Pigneur (2002) Business Model Ontology. For this hierarchy, the top level themes were coded as [Infrastructure ■], [Offering ■], [Customers ■] and [Finance ■]. These were the top level 'parent' themes. The 'child' themes were coded using the same colour scheme as the parents. For example, the child themes of [Infrastructure ■] were coded as [Activities ■], [Resources ■] and [Partners ■].

In a large part, the [Infrastructure /Activities ■] data on the company's business model was used to help sort the embedded studies into the two studies groups: cases considered in the 'TNC/MNC vehicle manufacturers' were characterised by their large sunk investments in equipment and tooling, and in their producing vehicles made from press-steel bodywork in the main, whilst those cases considered in the 'SME vehicle manufacturers' tended to use a broader variety of bodywork technologies necessitated by their lower volumes of production.

In terms of the [Finance ■] code, when coding research notes about [COST STRUCTURE ■] the nature of the research methodology and available resources used gives limited scope for an in-depth financial appraisal in terms of a quantitative comparison between different manufacturers. Moreover, because of the 'open' and transparent nature of this research, many manufacturers would find this information being in the public domain objectionable (This is one of the compromises of the 'open', 'un-anonymised approach to the research described in the section 4.7.1 Research Ethics beginning on Page 192).

Finally, a section entitled [Transitions ■] was created, which in turn was broken down into the sub tags [Niche ■], [Regime ■] and [Landscape ■].

If the code system were visualised as a structured hierarchy, it would appear thus:

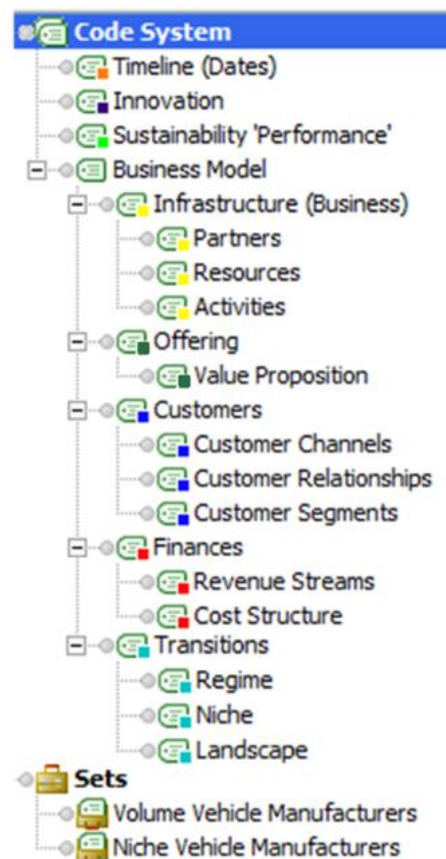


Figure 64 - Coding Schema as Visualised in MaxQDA Software

Through coding the data in this way, it was possible to navigate quickly between coded sections of data in different embedded cases. An example of a coded interview section is provided in Appendix 6.

## 4.9 Limitations of the method

There are some elements of the business model description where this study falls decidedly short of providing a full and rich description. The business model components '**REVENUE STREAMS**' and '**COST STRUCTURE**' do not entirely lend themselves to qualitative analysis, and a fuller picture would only be gained through some detailed exposition of companies' financial affairs. With the approach adopted by this study of overt and transparent research methods without anonymisation, clearly there is little scope for detailed analysis of what are currently well kept industry-secrets. It therefore cannot be considered a failure of this research that these areas are not described in the same level of detail as other components of the business model. Indeed, it would be hard to perceive any researcher conducting a cross-sectional comparative study such as this getting access to such information. Despite the lack of fine-grained comparative qualitative analysis, there were some clear trends that emerged from a discursive analysis of companies **COST STRUCTURES**.

Furthermore, the impact of different revenue streams could not be fully appraised without detailed accounting analysis. However, there is evidence of creative business model thinking exposed in the analysis of companies thinking 'beyond' the revenue streams that form the core of the traditional automotive business model. This provides glimpses into possible alternate futures for the industry. Whilst supplemental secondary data was used where possible to augment the primary data collected by the researcher, there are obvious limitations to what information firms are prepared to allow into the public domain. This to some degree means that the viewpoints constructed in the embedded case are somewhat from the perspective of an "outsider".

## 4.10 Chapter Summary

In this chapter, the practical details of the methods used to conduct the research were examined.

Methodology is essential to any piece of robust empirical work in establishing how the work is to be conducted, and how the methods used to explore the themes relate to extant theory and the epistemological and ontological approaches taken. As such, this chapter is core to understanding how the empirical work that follows in the subsequent chapters has been conducted.

In terms of the theoretical approach, Yin's (2009) 'Case Study' method provided an overall framework for the piece, dividing the empirical work into three main sections – the overall context and two case studies, one of 'large' firms, and the other of 'small'. The issues with dividing firms into the two categories was discussed as challenging and problematic. The division into the two case studies is imperfect, but a practical compromise.

It was established that the 'Business Model Ontology' would provide a framework for analysing the embedded case studies. These cases would be considered within a broader framework of 'transitions' which provides an overarching theoretical framework for considering the shift of an entire sector from one technology to another. The practical details of selecting the embedded cases, gathering the data and analysing that data were explored, as well as the limitations of the methods selected.

The next Chapter, provides a frame through which both of the case studies can be viewed, examining relevant contextual factors in which both cases are rooted.

The two case studies follow in the subsequent chapters; Chapter 6 (Case Study I – TNC / MNC Vehicle Manufacturers) and Chapter 7 (SME Vehicle Manufacturers).

This chapter also set out how the empirical data which supports this thesis will be gathered and analysed. This analysis is presented in Chapter 8, with conclusions stemming from this analysis being drawn in Chapter 9.



## Chapter 5:

### The UK Market for ULEVs : A STEP Analysis

As set out in the previous chapter, understanding context is generally considered crucial to the interpretation of case study research. In the preceding chapter the need to understand the external macro-environmental factors that affect the companies which operate in this field was underlined. This chapter comprises a 'STEP' (Socio-Cultural, Technological, Economic and Political) analysis of the UK environment into which VMs are introducing ULEVs. *"A STEP analysis is one way of collating current information on a new development across different influencers and to forecast how those influences may develop over time."* (SPA, n.d.). Additionally, *"The [...] analysis should be used to provide a context for the organisation's/individual's role in relation to the external environment."* (JISC, 2008).

Offer, Contestabile, Howey, Clague & Brandon (2011, p. 1949) discuss the importance of context in understanding ULEVs and state that *'Analysis that does not account for behavioural and market aspects leads to results that are removed from the context, and therefore do not provide the right information to policy-makers'*. Furthermore, Meadowcroft (2011) notes the importance of considering the political context in sustainability transitions. It is against this context that the diversity of solutions within the UK marketplace can be seen as firmly rooted in the automobility context (Wells P. E., 2010b, pp. 63, 66) within which they have been developed.

Margaret Thatcher described the UK as the *'great car economy'*. Included within the scope of this context is the perspective that, whilst personal mobility and, in particular, personal vehicles present manifold challenges from a sustainability perspective (previously, the need to sustain *'personal mobility'* has been argued on p. 5), they are an enduring component of the UK transport mix. Therefore, whilst sustainable transport strategies often mandate a reduction in demand, modal shift and reduction in private transport (See Figure 7, p. 28), efficiency improvements in the private vehicle mix are essential to improve the sustainability of transport in the UK. This analysis examines the contextual *'landscape and regime'* factors that have the potential to promote and obstruct these improvements.

## 5.1 A Socio-Cultural Perspective on UK Motoring

The concern of transitions scholarship is the evolution of socio-technical systems. Hence, social attitudes towards transport use, focusing on car use and perceptions of ULEVs, are central to this analysis. As Baiocchi, Minx & Hubacek (2010) highlight, in modelling a range of UK consumption behaviours across different regions, *'lifestyles are important for determining CO<sub>2</sub> emissions associated with UK consumption'*; they demonstrate, that per household or per capita, varying consumption choices can lead to between a factor 2-3 difference in CO<sub>2</sub> emissions. Therefore 75% of the UK's CO<sub>2</sub> emissions can be attributed to *'consumption choices'*. Themes discussed in the introduction are revisited to build the case that UK consumers' consumption choices are shaped by an expressed preference for private over public transportation (p.5), confirming the importance of greening private mobility.

Baiocchi, Minx & Hubacek (2010) find that transport emissions are particularly high for wealthier households. This is particularly interesting, as it is the wealthier consumers that have the resources to form the first tranche of early-adopter ULEV consumers. Indeed, there is a paradox in that, whilst those who consume the most have the greatest impact, they also have the spending power for the next generation of vehicle technologies to be within their financial reach.

UK consumers do express concern for the environment but presently are apprehensive about alternative vehicles. Whilst there is a focus on EVs in this respect (based on available data), many of the challenges consumers face with EVs can equally be applied to hydrogen vehicles, in that there is anxiety over range, performance cost and infrastructure availability. Other ULEV solutions, such as plug-in hybrids, have the potential to bridge the gap between the present vehicles that consumers are familiar with and future ULEV technologies; however, there is the trade-off that these often have lower "pure electric" ranges and, when the ICE is used to provide power, the environmental benefits are reduced significantly (Stephan & Sullivan, 2008; Shiaua, Samaras, Hauffe, & Michalek, 2007; Samaras & Meisterling, 2008).

### **5.1.1 The Habits of UK Travellers**

The following section provides information on the nature of travel and journeys in the UK, which informs the context of the market into which ULEVs are being introduced.

#### **5.1.1.1 Time Spent on Journeys in the UK**

Marchetti's (1994) thesis is that the average amount of time humans are prepared to spend travelling daily is a constant throughout society, and that the average distance a person will end up travelling is a function of the technologies available for transportation, their speed, and the infrastructures available for transportation. Thus, if societies have access to faster modes of transport, they will travel further but, on average, spend the same proportion of their time travelling. The data on UK travel in cars corroborates Marchetti's (1994) constant that, on average, people are prepared to spend an hour a day travelling. Melbourne (2013, p.3) notes that people in the UK spent on average 361 hours per year travelling in 2012 (across all modes of transport), which is down slightly from 369 hours per year in 1995/7. Considering that 89% of trips in 2012 were by private transport modes, this represents a significant amount of time spent in cars. With conventional vehicles, this time is spent consuming finite resources!

#### **5.1.1.2 The Length of Journeys in the UK**

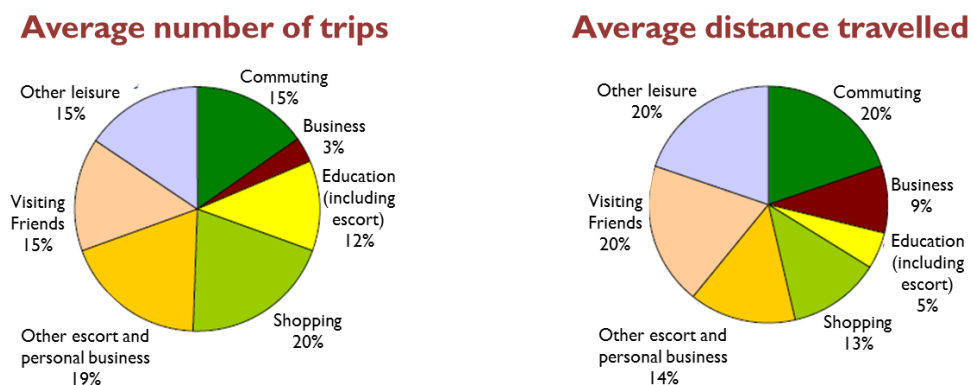
The annual distance that people travel has increased 49% over the 1970s, with much of this growth during the 70's and 80's. Trip *lengths* have increased by 50% since the early 1970s. Trip *rates* increased until the mid-1990s; however, since then have been gradually falling (Melbourne, 2013, p. 1). That said, the average journey distance is still well within the capability of a range of ULEV technologies. In 1995/7 the average journey distance was 6.4 miles and this compared to a 2012 figure of 7.0 miles. (Melbourne, 2013, p. 3). The effect of 'social variables' on journey types are made clear in the gender divide between journey types. The statistics reflect that men make fewer journeys than women but tend to travel longer distances (Melbourne, 2013, p. 1). There is a growing amount of technology in vehicles which can help to optimise journey lengths by routing the most appropriate route (Melbourne, 2013, p. 22) with the number of navigation systems in cars increasing from 31% in 2009 to 44% in 2012.



### 5.1.1.3 The Purpose of Journeys in the UK

Cars and the service of mobility that they provide are consumed for different reasons. In addition to providing the utility of being able to get from “A to B”, the “journey” also enjoys a cultural significance above and beyond the function and utility of transportation. A journey by car, cocooned in individual luxury, conveys a sense of pleasure that the same journey on a crowded Northern Line Underground train might not. A result of this is that many car journeys are not essential “*Like cigarettes, cars are a source of seductive pleasure that eventually comes to enslave its users*” (Soron, 2009, p. 187).

Comparing the types of journeys made by the number of trips and the average distance travelled gives insight into the length of those journeys (See Figure 65); by way of example, travellers make few business trips, but looking at the distance travelled, it can be seen that these trips tend to be longer.

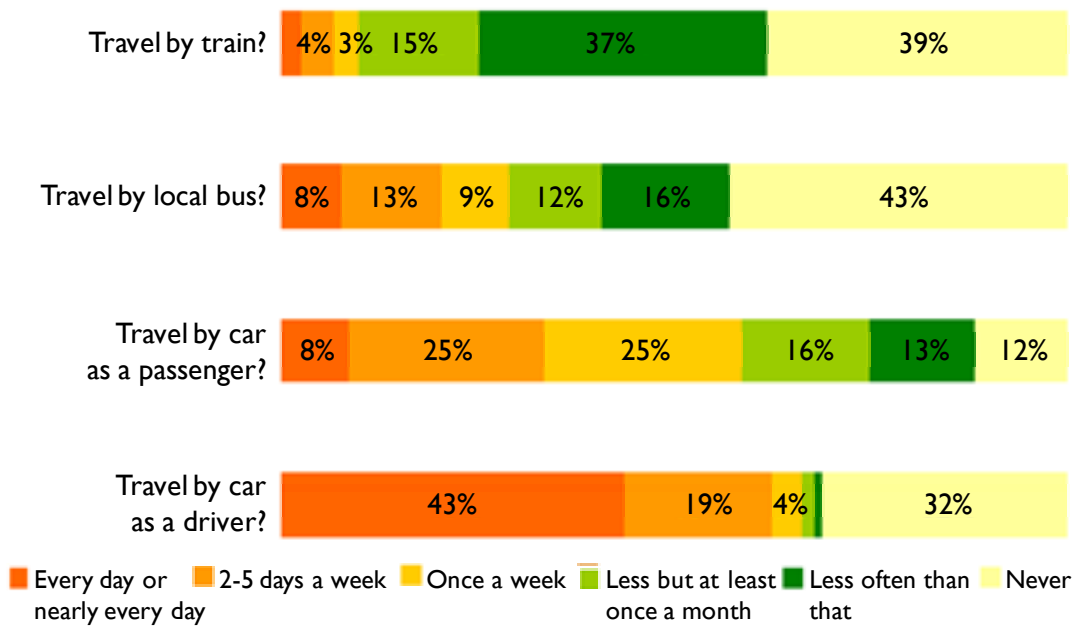


**Figure 65 - Average number of trips & Average distance travelled in 2012 by UK drivers  
Redrawn from Melbourne (2013, p.9)**

There are also broader changes in society which have the potential to reduce the need for journeys in certain categories. It may be possible to substitute some types of journey through changes in social practice. The increase in online retail may reduce the need for personal journeys made for shopping, as Edwards, McKinnon & Cullinane (2010) have found. Dematerialisation, ‘clicks not bricks’, delivery of services online and e-business may also reduce the need for some journeys for business or administration (James & Hopkinson, 2001). Similarly, telecommuting (Gillespie, Marvin, & Green, 2001, p. 205) has long promised the ability to work from home eliminating certain work journeys. These changes may occur but others caution against the hyperbole (Gillespie, Marvin, & Green, 2001, p. 200) used in describing the transformative effects of new technologies on consumer lifestyles.

### 5.1.1.4 Modal Split of UK Journeys

The British Social Attitudes Survey (NatCen, 2010) reveals that, from the sample of those interviewed in the UK, public transport is used to a much lesser degree than private transport. Of those interviewed, over 66% travel by car as a driver at least once a month, whilst 84% travel by car as a passenger once a month. By contrast the figures for public transport use rank much lower. These statistics are expanded in Figure 66.



Source: 2010 British Social Attitudes Survey (NatCen)  
 Unweighted base count 3,297 (all CAPI respondents)  
 Note: Data labels are not presented for values of two per cent or less.

**Figure 66 - British Attitudes to Using Different Modes of Transport (NatCen , 2010)**

This data is supported by Melbourne’s (2013, p.5) statistics, which says that 50% of UK journeys by distance and 42% by number of trips are undertaken with the journey maker as a driver in a van or car. Similarly, 28% of UK journeys by distance and 22% by number of trips were undertaken with journey maker as a passenger in a van or car. In 2012 (Melbourne, 2013, p.5) 64% of all trips travelled, and 78% of all transport by distance was undertaken by car.

These statistics serve to highlight the enduring centrality of the car as the most dominant component of the UK transport landscape. Whilst modal shift is desirable achieving it will be hard.

### **5.1.1.5 London: A Special Case?**

Within the UK context, one region is particularly anomalous in terms of travel behaviour - London.

One of the biggest changes in the statistics has been to the London area. London has been operating a congestion charge which acts as a financial disincentive to using cars in the congestion charging zone. Melbourne (2013, p.6) notes that between 1995/7 and 2012, car use in the capital decreased by 37%.

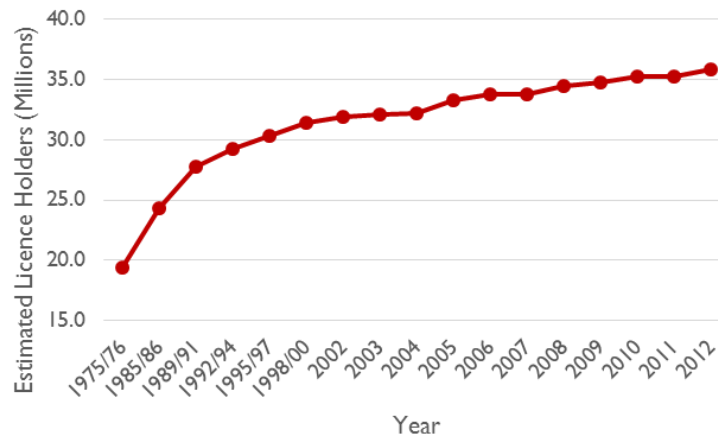
This has been accompanied by a corresponding rise in public transport use. The distance of journeys undertaken by London bus has increased by 55%, which can be set against a context of a 17% fall in bus journeys outside of London (Melbourne, 2013, p. 7). The distance of passenger miles undertaken on surface rail in London has increased by 73% (Melbourne, 2013, p. 7). Bicycle use has also benefited from the congestion charge, increasing by 63% in the period 1995/7 to 2012 by 73% (Melbourne, 2013, p. 7). This is highly significant given that it is three times the national average.

Furthermore, there is a particular incentive for those who make frequent journeys into London to engage with ULEVs. Being exempt from the Congestion Charge, there are significant cost advantages to owning a ULEV in Central London, and perhaps this has been partly responsible for stimulating the early market in electric vehicles in these areas? The Congestion Charge in London has reduced vehicle use in the city, and there is evidence to suggest that an exemption encourages EV ownership (Kley, Wietschel, & Dallinger, 2012) notwithstanding the irony that this also simultaneously thwarts the primary political objective - namely to reduce congestion! Hence this is not a sustainable strategy and works only for the early market. There are other incentives that make EV vehicle ownership particularly attractive in London. Some boroughs provide discounted parking that can be worth up to £6000 every year (Leurent & Windisch, 2011).

This incentive helped London to secure an early lead in EV uptake, particularly in respect to early G-Wiz quadricycles that entered the market some time ago; however, Plugged In Places has created incentives for EV use in other regions of the UK.

### 5.1.2 UK Driver Demographics

The number of drivers in the UK continues to grow inexorably. The Department for Transport statistics show a trend which shows no sign of abating. Drivers in turn create demand for vehicles.



**Figure 67- Growth in Estimated Driving Licence Holders in the UK**  
**NB: Distortion to the y-axis results for available statistics.**

The proportion of men holding driving licences has remained stable; the proportion of women holding licenses has increased since the mid 1990's (Melbourne, 2013, p. 4). The proportion of young license holders is falling, with most citing economic reasons as the main barrier to learning to drive, whilst the proportion of elderly drivers holding licenses is increasing (as a function of ageing existing licence holders) (Melbourne, 2013, p. 4). This may point to a generational cultural change in car use.

Melbourne (2013, p. 17) cites access to a car as one of the most important variables affecting members of household's level of mobility. Members of households with access to a car tended to make 51% more trips and travelled twice as far as households without access to a car. Referring back to Banisters' (2008) transport hierarchy, these statistics reinforce the need for modal shift and transport reduction. Melbourne (2013, p.18) also suggests a strong correlation between income and the distance travelled. Again, this feeds back into the challenge that, whilst it is the wealthiest who have the biggest impacts, their resources give them the greatest range of options for change, and so this group is likely to form the early market as ULEVs transition into the marketplace. The number of people on average in a vehicle in use has also remained fairly constant, with an average of 1.6 (Melbourne, 2013, p.22).

### 5.1.3 The UK Media, Society & ULEVs

Consumers are influenced not only by marketing and advertisements from car manufacturers, but also the broader cultural context; one component of which is the UK media. Kemp, et al., (2010) note the powerful effect of the motor media on consumer behaviour. They also note how the car is captivating as an object of consumption, noting that 6.4 million UK viewers would not tune in to a programme called 'Top Domestic Appliances' or 'Top Condensing Boilers' in the same way that they do to 'Top Gear'. The phenomenon of 'Top Gear' has become so popular that it has even been the subject of scholarly investigation. UK cultural conceptions of automobility, as demonstrated through the UK media, are of international significance in leading and shaping global opinions on matters of motoring. Bonner (2010, p. 32) cites two sources, with the producers claiming Top gear reaches 500,000,000 globally, whilst *Auto Express* magazine claims that *Top Gear* reaches a billion people in 117 countries (Wengraf, 2013). Where this presents a challenge, from a sustainability perspective, is that the ethos and values that the programme glamourises and promotes run counter to values that might be considered sustainable.

***Freedom from all restraints is the programmes obvious ideal; contempt for environmental consciousness, speed cameras and other attempts to improve road safety, and for fellow road users who obey rules, all demonstrate this.***

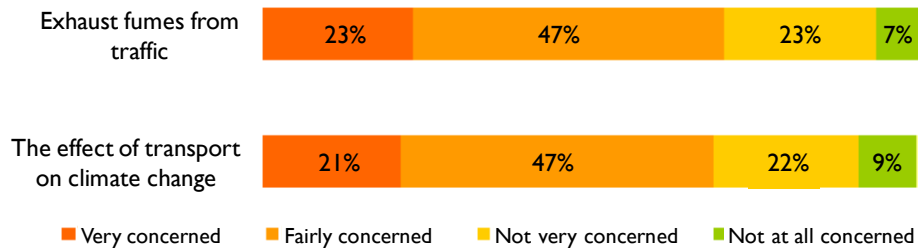
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**(Bonner, 2010)**

This runs contrary to the notion of 'constraints' imposed by resource shortages and the imperative to combat anthropogenic climate change. The attitudes promoted through such entertainment produce additional challenges in shaping public opinion and behaviour towards ULEVs. However, *Top Gear* is but one element (albeit a very significant one) of a healthy and vibrant culture of automotive journalism in the UK, of which Noakes (2012) provides a comprehensive and contemporary coverage. Brady (2010, p. 15) notes the increase in UK media coverage of electric vehicles, but states that coverage of Ultra Low Emission Vehicles is not universally positive. In particular a EuroNCAP test of the GWiz performed by the programme *Top Gear* caused sales of the quadricycle to fall two thirds in the subsequent weeks (Murray, 2007). Page (2007) notes that the DfT released a statement three days before the programme aired, noting that they were investigating a change of legislation following similar (!) tests performed at another location. Sparkes (2007) notes a degree of unfairness given that, at low speeds experienced in congested use, quadricycles are unlikely to experience the same impacts as experienced in the EuroNCAP tests. It may also help explain poor UK policy support for quadricycles.

### 5.1.4 Attitudes to Environmental Problems

Despite consumer concern regarding ULEVs, those polled by the British Social Attitudes Survey (NatCen, 2010) expressed concerns for both the exhaust fumes that result from traffic (70% being fairly concerned or very concerned), and the effect of climate change (where 68% are either fairly concerned or very concerned) This is illustrated in more detail in Figure 68.



Source: 2010 British Social Attitudes Survey (NatCen)  
Unweighted base count 3,297 (all CAPI respondents)  
Note: 'Don't know' and 'Refused' categories are not presented in the chart legend

**Figure 68 - British Attitudes to Transport Related Environmental Problems (NatCen, 2010)**

It appears that there is a profound disconnect between consumer awareness of the impact of conventional vehicles and consumer acceptance of the alternatives. This disconnect extends, not just to product selection, but also to driver behaviour. In the next section, this thesis will show that, despite continual technical improvements to vehicle efficiency, the “on road” emissions of the UK vehicle fleet are much higher, and a component of this is driver behaviour (Bonilla, 2009).

This is a challenge that needs to be addressed and it is an issue of culture. Lane & Potter (2007) have used ‘Theory of Planned Behaviour’ models in order to try and understand the “attitude-action” gap. They conclude that the relationships between fuel input, vehicle use and emissions are poorly understood, if at all, by drivers (Lane & Potter, 2007, p.1088). Furthermore, knowledge of the relative advantages and disadvantages of the alternatives is generally poor. Whilst concern for the economics of running a car is very high (Lane & Potter, 2007, p.1088), the knowledge of how the running costs of a car break down is very low. This poor understanding about the underestimating the benefits of the new technology, whilst overestimating the benefits of the old, returns to ideas explored by Gourville (2006) on p.80. Attitudes may also be explained by some of our cultural associations with the car.

### 5.1.5 Cultural Dimensions to the UK Carscape

There are a number of interesting cultural dimensions to the UK automobility system which set the UK apart from other nations. This distinctive character of the UK automotive industry is important to consider when analysing the business context for innovative business models.

The UK is a large market for imported vehicles, with 70% of new car sales coming from overseas (Wells, 2010b, p. 63). With MG Rover's demise, there is no longer a 'domestic champion' taking brand ownership into consideration (i.e. UK owned volume vehicle maker) (Wells, 2010b, p. 63).

Nieuwenhuis (2008) points to the concept of 'emotional durability', citing the work of Nilstad Pettersen & Boks (2007). Nieuwenhuis (2008, p.653) builds the case that it is "*possible to extend the useful life of a car far beyond the current norm in the developed world*" by creating an emotional attachment to historic and classic vehicles. Despite its small relative size, Nieuwenhuis (2008) notes that the UK is home to the largest concentration of classic vehicles in the EU, noting that 1.3% of vehicles on the road in the UK are classic or historic vehicles (stating this is an achievement given its damp climate). There is an unusually high number of enthusiast car clubs in the UK (Wells, 2010b, p. 63) and a culture of interest in historic vehicles, niche marques and motorsport (Wells, 2010b, p. 66). This accounts for the large number of low-volume specialist assemblers, SME VMs and diversity within the models, body styles and vehicle variants offered for sale in the UK marketplace (Wells & Morreau, 2009).

However, Nieuwenhuis (2008: 653) describes the challenges in transferring this approach to mainstream, modern, mass produced vehicles. Three core elements of the enduring appeal of classic vehicles according to Nieuwenhuis (2008: 653) are rarity, an appeal to nostalgia and simplicity of maintenance. Some types of ULEV drivetrain, e.g. electric vehicles, have potential to reduce the burden of maintenance. Low volume production vehicles are a distinct niche and potential protected space for ULEV development. Whether manufacturers can create truly iconic ULEV designs that stand the test of time is impossible to predict. The existence of these interesting and divergent niches within the UK car scape perhaps provides opportunities for other niche-actors by virtue of the UK's unique and sometimes eccentric cultural relationship with vehicles.

### 5.1.6 Attitudes Towards Electric Vehicles

There have been a number of past studies that looked to evaluate consumers' willingness to pay for electric vehicles. Many of these studies are international in nature, and not specific to the UK context. These are summarised by Hidrue, Parson, Kempton & Gardner (2011, p. 688) – (Beggs, Cardell, & Hausman, 1981; Calfee, 1985; Bunch, Bradley, Golob, Kitamura, & Occhiuzzo, 1993; Brownstone & Train, 1999; Brownstone, Bunch, & Train, 2000; Ewing & Emine, 2000; Dagsvike, Wetterwald, Wennemo, & Aaberge, 2002). It is important to note that many of these studies are now over a decade old, during which time the lifecycle running costs of conventional vehicles has risen with the increasing cost of petrol. Indeed consumer preferences may have changed in this period due to increasing awareness of both environmental challenges and the alternatives to ICE vehicles.

The study by Hidrue, Parson, Kempton, & Gardner (2011) is one of the most recent studies on consumer willingness to pay for EVs, but it is important to note that it is a US study and so the attitudes may not be directly comparable to that of the UK consumer.

Some of the general findings (Hidrue, Parson, Kempton, & Gardner, 2011, p. 704) were that youth, education, green lifestyle, access to electricity and a belief that petrol prices will increase all act as positive indicators for the propensity of a consumer to purchase an EV. Furthermore, if the consumer already purchases small / medium sized vehicles or hybrid vehicles, this also acts as a positive indicator for EV purchase. This view is supported by Contestabile, Offer, & North, (2012)

It was estimated by Hidrue, Parson, Kempton, & Gardner (2011, p. 704) that, out of 3029 respondents, most would be willing to include the cost of around 5 years of fuel saving into the purchase price of an electric vehicle. They were also willing to pay between \$35-\$75 per mile for additional range, and between \$424 and \$3250 per hour reduction in charging time. In all, this factored into a willingness to pay between \$6000 and \$16,000 over the purchase price of a petrol vehicle. They go on to say that for electric vehicles to be a realistic proposition without subsidy, battery costs need to decrease substantially.



### 5.1.7 Consumer Concerns about Electric Vehicles

Consumers consistently express several concerns about electric vehicles. Hidrue, Parson, Kempton & Gardner (2011, p. 704) cite 'range anxiety', 'long charging time' and 'high purchase price' all as reasons which consumers express would hold them back from purchasing an electric vehicle. Range anxiety is a persistent theme in both the interviews conducted for this research with vehicle manufacturers and those involved with the sphere of policy making and governance alike. In research conducted with the BMW MINI E [See page 271], Franke, Neumann, Bühler, Cocron & Krems (2011) found that, whilst acknowledging previous work on vehicle range as a barrier to consumer uptake of electric vehicles by Bunch, Bradley, Golob, Kitamura & Ochiuzzo (1993), the perceived range barriers associated with ULEVs were overcome by implementing a number of psychological interventions, such as information, training and improved user-interface design. One of the findings, was from a usability perspective, in that a 'reliable usable range' may have greater importance than the ultimate 'maximum range' of vehicles. Whilst this doesn't suggest that range should be dismissed as an issue with ULEV adoption, it does suggest that the problems centre more on consumer perception than actual usability. This is supported by Neil Butcher, in an interview with Sunderland (2010), who suggests that early field data from UK trials shows a 'virtuous circle' of motorists experiencing the performance of current electric vehicles and realising that the technology can meet their expectations today.

As well as having implications for manufacturers' ULEV **VALUE PROPOSITIONS**, this also has profound impact on the way that infrastructure is deployed, and in the early-stage market for electric vehicles, this may have a bearing on regional marketing strategies for VMs. Wells (2010b, p. 62) explains how car manufacturers tend to have enhanced sales in their local areas, citing Nissan in Sunderland as one example. Indeed, infrastructure strategy in the UK has focused on creating "clusters" of recharging points to create critical density in early markets. Here, Nissan is a good example, as the North East comprised one of the first "Plugged In Places" schemes, and this was crucial to securing Nissan's investment in producing EVs at the site. If consumers have confidence in the brands at the heart of their communities and trust those brands, then there is the potential for those brands to lead systemic change, starting in the communities in which they command respect and confidence.

### **5.1.8 Public Education for ULEVs**

Since Rogers' (1962) work of the same name on the 'diffusion of innovations', it has been observed that 'innovators' and 'early adopters' tend to be more educated than the late market (Loy, 1969, p. 80). Studies in other markets have identified that in consumers that are very early adopters of electric vehicles, the level of consumers' general education is one of the factors that sets those early adopters apart (Hidrué, Parson, Kempton, & Gardner, 2011, p. 704). This was also echoed by a study from Deloitte (2011). In the UK, reports by fleet vehicle provider Alphabet (2012), cited by Hudson (2013) suggests that poor knowledge about EV benefits is one of the major barriers to adoption. This theme is also echoed by Lane & Potter (2007) [whose work has already been discussed on p.218].

Others have identified that public education is important to catalysing the early market for electric vehicles (Hensley, Knupfer, & Krieger, 2011, p. 3). Lane & Potter (2007, p. 1087) [in a UK study] identify that, whilst there is consumer concern about the impacts of vehicles, there is only a moderate understanding of the benefits of ULEVs.

### **5.1.9 The Social Impacts of the UK Automotive Industry**

According to the SMMT (2013), in recent years the UK automotive industry has made progress on a number of social goals. From those signatories that responded in the period 2011-2012 [representing 95.6% of the industry], the number of jobs dependent on the UK automotive industry rose from 79,641 in 2011 to 83,308 in 2012 (SMMT, 2013, p. 2), an improvement of 4.6%. Furthermore, the number of lost time incidents had also decreased by 3.8% down from 185 in 2011 to 178 in 2012, a reflection of an industry making a safe working environment for employees (SMMT, 2013, p. 2).

That said, there are also some social indicators on which the industry has failed to improve. Using the SMMT's own analysis of the whole automotive industry, the number of jobs dependent on the sector had fallen from 746,000 in 2011 to 731,000 in 2012 (SMMT, 2013, p. 2). Furthermore, in those respondents surveyed, the SMMT noted a decline of 14.8% in the number of training days per employee, falling from 3.2 to 2.7 days per annum (SMMT, 2013, p. 2).

## 5.2 Technology & Change in UK Motoring

In the introduction to this thesis, the goal was articulated of improving the sustainability of personal mobility (p.5), noting that, whilst broader systemic change was required to move towards sustainability (p.28), the persistence of cars as a mobility solution desired by consumers (p.30) inevitably lead to them remaining a significant component of the transport discussion. In looking at the evolution of the car industry's business model, it has been discussed how the business model mediates between the 'technical' and 'economic' domains of the business (p.89). Chapter 3 also explored some proposed radical business models (p.157) in the international landscape, many of which exhibit radical technology elements. In this section, the focus turns to the UK context, and examines some of key elements of the technology discourse and current practice relating to ULEVs.

A brief point to mention at this juncture is that, whilst this thesis is primarily interested in vehicle technologies, unlike conventional ICE vehicles where the carbon content of petrol or diesel fuel is a fixed physical quantity, the carbon content of electricity and hydrogen as secondary energy vectors is variable and dependent on the technologies used to produce it. The question of an 'energy transition' is enormous and diverse, and so it would be impossible to even touch on this parallel socio-technical transition in any meaningful way within the confines of this thesis. For this reason a "relative" approach has been taken in the definition of what constitutes a ULEV. This thesis is also technology agnostic considering all pathways to ultra-low emissions mobility in the round. As previously highlighted in the methodology, this is not a technical thesis seeking to appraise the quantitative improvement various technologies offer and is more a thick description of the business models and how they shape transitions. To understand this transition in technological terms, this section starts with the existing vehicle stock, examining performance in terms of GHG emissions. This looks at trends in vehicle economy (which correlates directly with emissions) but situates improvements in economy against a picture of increasing emission from road transport. This then proceeds to a discussion about roadmaps for future technologies seen through the eyes of the industry, and a discussion of what technologies may be introduced to the UK vehicle stock and what infrastructure(s) will be needed to support them.

## 5.2.1 The UK Vehicle Stock

The average age of the vehicle stock in Britain is steadily increasing. In 2009, cars registered in Great Britain had on average been licensed for 7.1 years, compared to figures for 2003 where licensed vehicles had on average been registered for 6.6 years. This trend is also mirrored in figures for motorcycle registration, where the average age of licensed motorcycles was 10.7 years in 2009 versus 9.6 years since first registration in 2003. These figures undeniably represent improvements in vehicle longevity and durability. Long-lasting products represent an improvement in sustainability terms (Wells P. E., 2010b, p. 66; Nieuwenhuis P., 2008), but they also represent a challenge from the point of achieving technology transitions. If a net improvement in vehicle emissions entails replacement of large swathes of the vehicle stock, the long lifetime of vehicles coupled with the long product development lifecycles of vehicle manufacture, present effective resistance to rapid change.

One of the trends observed is the “dieselisation” of the UK motor fleet (Bonilla, 2009, p. 3769). In one respect, this is positive as diesel vehicles are more efficient than petrol engines. Conversely, as diesel engines are more durable, users tend to cover more miles in diesel vehicles over its lifetime.

	1975	1980	1990	1995	2005	% change pa. 1975–2004
Vehicle stock (1000s registrations)	12,526	14,660	19,742	20,505	26,208	+2.49
Fuel economy new petrol cars (l/100 km) (excludes 4×4s)	–	9.3	8.2	8.1	7.4	-
Fuel economy (includes (4×4s); gasoline cars) (l/100 km)	–	-	-	8.28*	7.50	–
Fuel economy (includes (4×4s); diesel) (l/100 km)	–	–	–	7.10*	6.28	–
On road fuel economy (petrol equivalent l/100 km diesel & petrol)	10.35	10.45	9.66	9.35	9.90	-0.14*
Vehicle km (billions per year)	182	227	328	351	397.2	+2.6
Energy consumption (million tonnes)	14.50	17.26	22.46	22.04	22.26	+1.44
Emissions CO <sub>2</sub> (million tonnes of carbon equivalent)	12.53	15.3	19.3	18.9	19.36	+1.46

**Table 16 - Trends in private car transport in the UK in 1975–2004 – Copied From: Bonilla (2009, p. 3770)**  
**\*Calculated figure, omitted in original work. Negative figure shows decrease in consumption**

Despite technological improvements in the fuel economy of new cars, the “on road” fuel economy of UK motor vehicles is lower (Bonilla, 2009, p. 3769). Whilst this gap is narrowing, it is still significant. Furthermore, “on road” fuel economy is also impacted by driver behaviour. Bonilla (2009, p.3770) makes the case that the average speed travelled is elastic with income and wealth, and notes many drivers do not drive at the optimum speeds that result in best fuel economy. This results in increased emissions from the UK vehicle stock, despite the growing efficiency of the fleet.

## 5.2.2 Emissions from UK Transport

In order to understand the growing vehicle emissions of the UK fleet, there is a need to contextualize these emissions against other sectors in the UK economy.

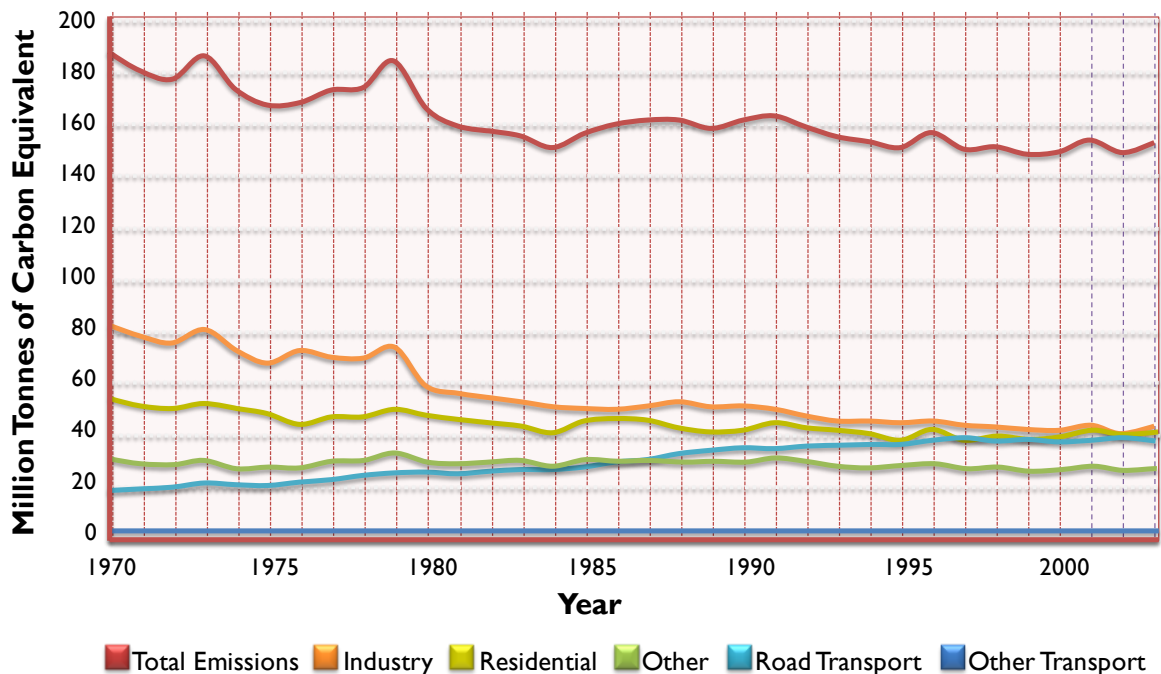
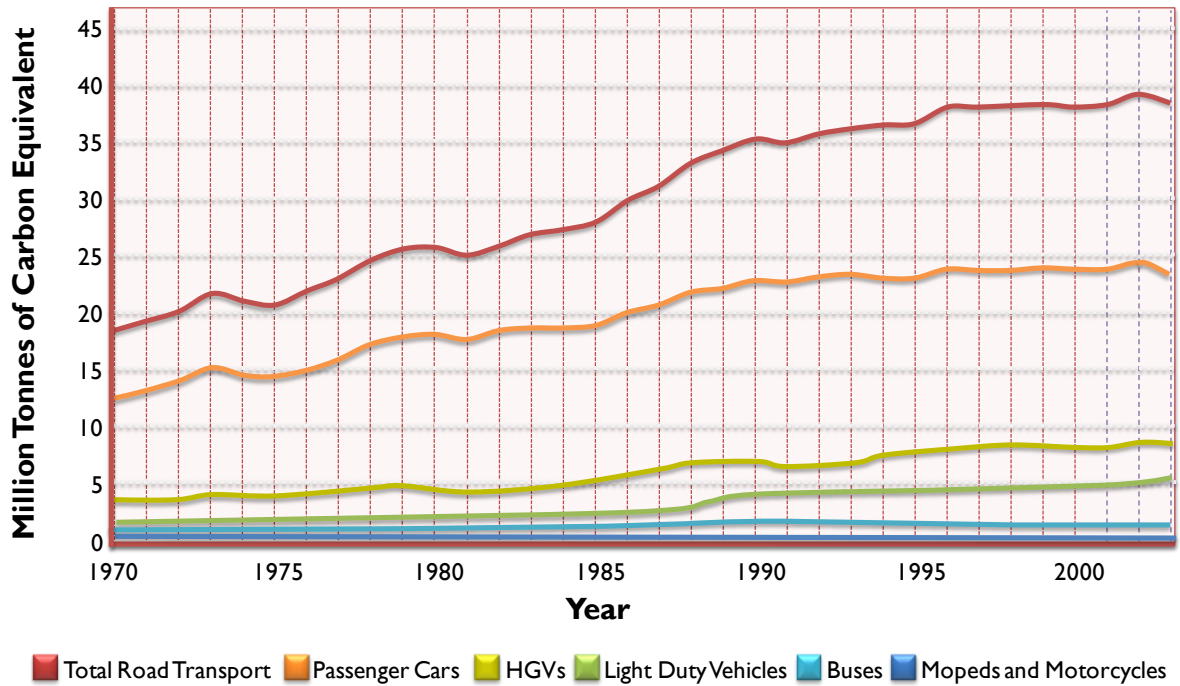


Figure 69 - GHG Emissions in the UK from (Department of Energy and Climate Change, 2010)

UK total emissions have, on the whole, since 1970 declined. In large part, this can be attributed to the widespread shift from carbon intensive generation using oil and coal to natural gas. This followed a relaxation on the ability to use natural gas for electricity generation that accompanied the liberalisation of energy marketplaces across the EU. Emissions from UK industry have also declined but this can largely be explained by the decline in UK industry, manufacturing and transition to an economy that is more reliant on the service sector. Residential emissions have also declined slightly, whilst “other” emissions stayed relatively constant in the period 1970 – 2005. Road transport bucks the trend.

It is therefore all the more significant that, against this backdrop of largely falling or maintained emissions, the largest grown in carbon emissions should come from road transportation. Breaking down road transport emissions by vehicle type, a clearer picture of the nature of emissions emerges. Emissions from Mopeds and Motorcycles are negligible, and the most significant increases in transport emissions come from ‘Passenger cars’, ‘HGVs’ and ‘Light Duty Vehicles’.



**Figure 70 - Emissions from different vehicle types –(Department of Energy and Climate Change, 2010)**

The Department of Energy & Climate Change (2010, p. Annex B) makes predictions for the growth in UK carbon emissions from Road Transport. In the baseline scenario, DECC predict a rise from 113 MtCO<sub>2</sub> / per annum in 2010 to 118 Mt / CO<sub>2</sub> per annum in 2025. This is without any government intervention, as set out in the Low Carbon Transition Plan policy. The Department then present a range of scenarios differentiated by forecast oil prices with the policy measures taken into account. They predict a spread of scenarios ranging from the ‘low fuel price’ scenario emissions of 96 Mt / CO<sub>2</sub> per annum to the ‘high high’ price scenario emissions of 89 Mt / CO<sub>2</sub> per annum; both by 2025. Under (Department for Transport, 2010, p. Annex F) ‘High High’ predictions, the weighted average (taking into account RON95 & RON 97 Unleaded and DERV) for the cost of a litre of motor vehicle fuel will rise to 162p / litre by 2025 from its 129.8/ litre 2010 baseline.

This reinforces that the scarcity of fuel will drive up its price. However, this does not prevent increasing emissions from the sector. These rises cannot be considered acceptable in the context of a need to reduce emissions. Having explored the impact of vehicles in use, attention turns to the impacts of producing vehicles.

### 5.2.3 The Environmental Performance of the UK Motor Industry

In the SMMT's (2013) Sustainability report [and accompanying historical data set (SMMT, 2013)], a range of environmental performance indicators were given for the UK vehicle industry. To represent this data (which is on different scales and in different units), in Figure 71, the SMMT data has been transformed by indexing these figures against a 100% baseline for a vehicle produced in 2012. (Original figures [Table 17] & SMMT Infographic [Figure 72] reproduced overleaf). For reference, data on the number of UK volume passenger car manufacturers and the number of UK cars produced is also given. The original dataset contains environmental impact data by the number of vehicles produced, by numbers of employees, per £ million turnover and per vehicle produced. In Figure 71, the figures for 'per vehicle produced' were used as these best reflect the overall eco-efficiency of vehicle production in the UK. The 'per £ million turnover' figures are susceptible to distortion as a result of general economic and foreign exchange fluctuations.

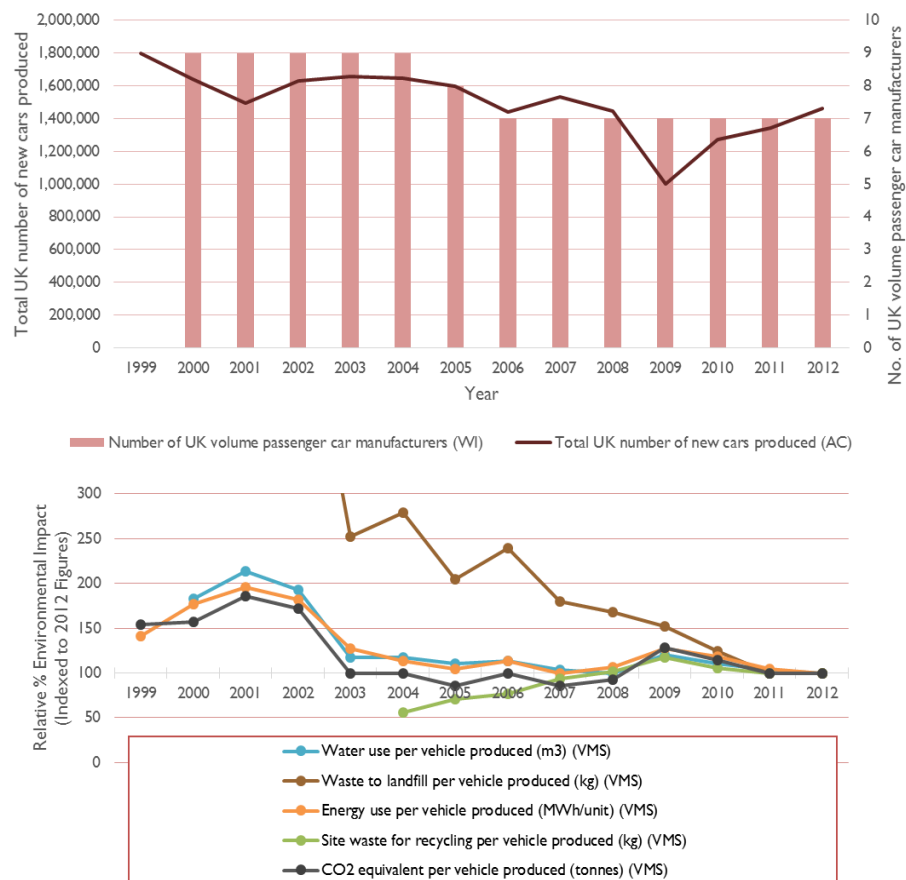


Figure 71 - Improvement in the UK Car Industry on a Range of Environmental Indicators

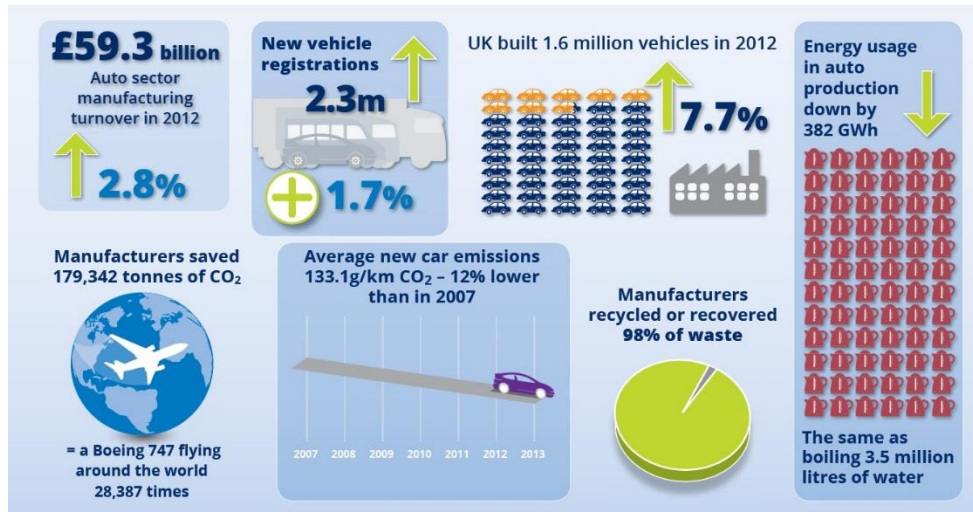


Figure 72 – SMMT Sustainability Report Infographic (SMMT, 2013)

		2011	2012	Percentage change 2012 on 2011	
<b>ECONOMIC PERFORMANCE</b>					
Automotive manufacturing sector turnover*	(£ billion)	57.7	59.3	2.8	●
Expenditure on business R&D*	(£ billion)	1.5	1.7	9.2	●
Total number of cars and CVs produced	(million) (UK) (WI)	1.5	1.6	7.7	●
Total new cars and CV registrations	(million) (UK) (WI)	2.2	2.3	1.7	●
Signatories' combined turnover	(£ billion) (AS)	49.6	58.2	17.5	●
Total number of vehicles produced	(million) (AS)	1.4	1.5	9.4	●
<b>ENVIRONMENTAL PERFORMANCE</b>					
<b>Production inputs</b>					
Total combined energy use	(GWh) (AS)	5,010	4,628	-7.6	●
Energy used per vehicle produced	(MWh/unit) (VMs)	2.3	2.2	-4.8	●
Total combined water use	(000m <sup>3</sup> ) (AS)	5,481	5,765	5.2	●
Water use per vehicle produced	(m <sup>3</sup> /unit) (VMs)	3.0	2.9	-2.1	●
<b>Material output</b>					
Total combined CO <sub>2</sub> equivalents	(tonnes) (AS)	1,600,148	1,420,805	-11.2	●
CO <sub>2</sub> equivalents per vehicle produced	(tonnes/unit) (VMs)	0.68	0.66	-3.2	●
Volatile Organic Compounds emissions (cars)	(g/m <sup>2</sup> ) (VMs)	35.4	35.3	-0.2	●
Volatile Organic Compounds emissions (vans)	(g/m <sup>2</sup> ) (VMs)	61.4	60.5	-1.4	●
Total combined waste to landfill	(tonnes) (AS)	14,780	11,661	-21.1	●
Waste to landfill per vehicle produced	(kg/unit) (VMs)	7.1	5.9	-16.7	●
<b>Vehicle use</b>					
Average new car CO <sub>2</sub> emissions	(g/km) (AC)	138.1	133.1	-3.6	●
<b>SOCIAL PERFORMANCE</b>					
Number of jobs dependent on the sector*	('000) (WI)	746	731	-2.0	●
Combined number of employees	(AS)	79,641	83,308	4.6	●
Number of lost-time incidents	(AS)	185	178	-3.8	●
Number of training days per employee	(AS)	3.2	2.7	-14.8	●

(WI) Whole industry data; (AC) All car registrations in the UK; (AS) All signatories; (VMs) UK vehicle manufacturer signatories; (CV) Commercial vehicles; (CO<sub>2</sub>) Carbon dioxide.

The report has 19 signatories which represent 95.6% of vehicle production in the UK. This includes three new signatories and two signatories becoming a single legal entity – Jaguar Land Rover Ltd.

The 2011 and 2012 data have been adjusted to take into account new signatories and enable year-on-year comparison.

\*Sector turnover, R&D and jobs dependent on sector are compiled from several official sources using expert SMMT analysis.

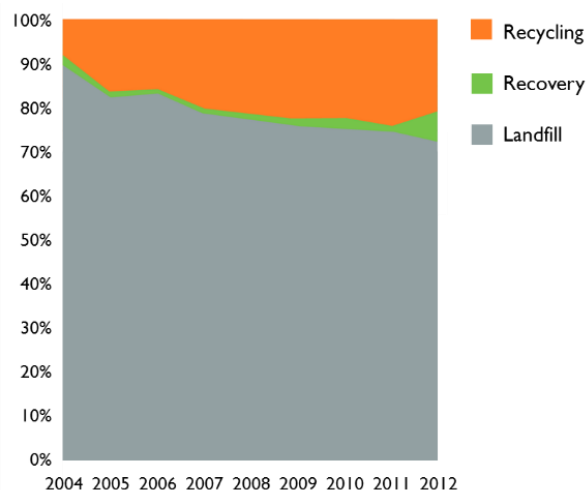
The 2011 data has been revised with more up-to-date information since the previous report and the 2012 figures are based on projections.

Table 17 SMMT's (2013) Sustainability Report



Overall, the metrics show a general trend of improvement over the past decade. There are two notable dips in performance; these are centred on the years 2001 and 2009. It can be seen by looking at the production figures transposed above that both of these years correspond with years when production figures suffered. This transient decline in performance is perhaps indicative of the economies of scale inherent in the incumbent large scale production business model having high fixed overheads. By way of example; the factory still needs to be lit / heated even if it produces half the cars. Over the past decade, as illustrated in Figure 71, the UK motor industry has demonstrated a consistent gradual improvement in its environmental impact across a range of measures.

The SMMT (2013, p. 4) also reference manufacturers' attempts to reduce energy consumption in vehicle manufacture. Energy conservation has been mirrored by a commensurate reduction in carbon emissions. Furthermore, there have been investments by manufacturers to increase the penetration of renewable energy into their manufacturing operations – delivered by a combination of on-site renewables and sourcing energy from green providers (SMMT, 2013, p. 4). That said, the SMMT note significant challenges to radical improvements in efficiency where some equipment operates on very long replacement cycles (2013, p. 4). Waste management is also an area which shows significant improvement in the last decade. Figure 73 is redrawn from SMMT (2013, p. 5)



**Figure 73 - Changing patterns of waste management in the UK car industry.  
Modified from: SMMT (2013, p. 5)\***

\*N.B: The original figure shows the y axis range as 100% - 70%. This creates a more dramatic impression of the improvement in waste management practice. Here, redrawn extending the y axis to 0% to show room for improvement.

### 5.2.4 Industry Vehicle Technology Roadmaps

A number of groups have been tasked with creating a consensus for strategic growth within the UK industry. These are useful groups to turn to in order to understand potential future vehicle technology roadmaps. In common with other countries around the world, the policy regime in the United Kingdom has been broadly supportive of a range of different technology trajectories for decarbonising vehicles. These come together in the following roadmap, which is indicative of a range of various similar proposals. A common theme seems to be that degrees of hybridisation act as a bridge to electrification, with fuel cell vehicles following shortly after mass market penetration of EVs.

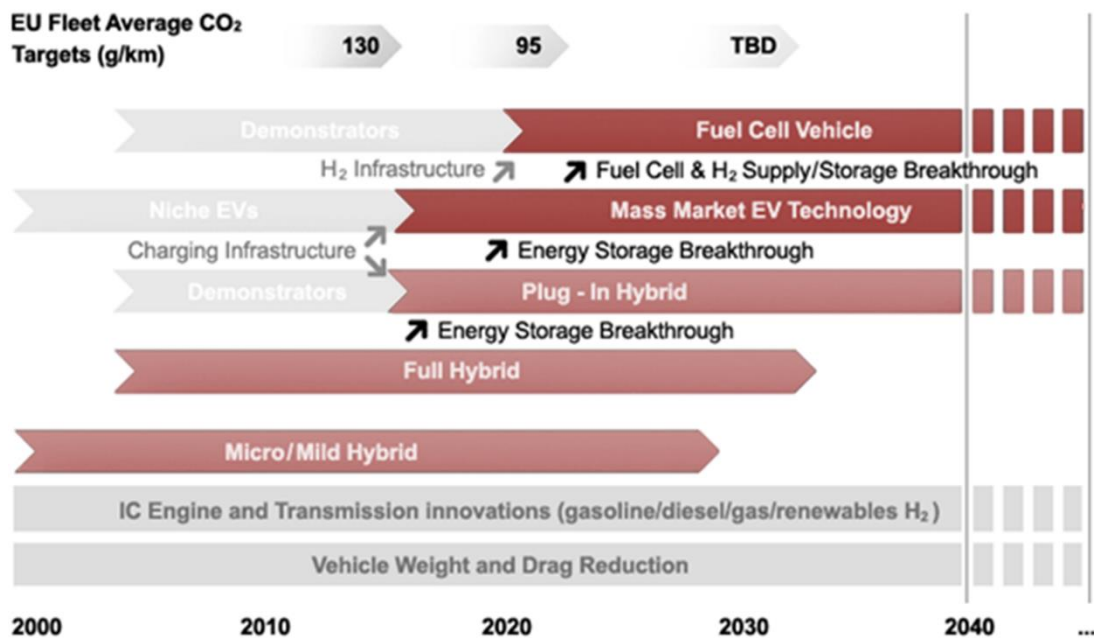


Figure 74 - A ULEV Vehicle Roadmap, as proposed by the Automotive Council (2013)

Hybridisation is convenient as, in retaining the benefits of petrol / diesel vehicles, there are no challenges with the availability of infrastructure. This is why hybrids are seen as an intermediate solution. Plug in hybrids offer the convenience of both operation from petrol/diesel, but with the environmental benefits of being able to run the vehicles for a limited mileage from electricity.

Pure EVs and Hydrogen vehicles, however, require infrastructure for their deployment which is why many roadmaps place their adoption at a later date. The next section appraises the relative benefits of a range of ULEV technologies.

### 5.2.5 Appraising ULEV Vehicle Technologies

Within the UK, there are a variety of technology solutions that are in the process of reaching the market. On Table 3 p.35, the range of alternative drivetrain technologies being examined by manufacturers are examined generically.

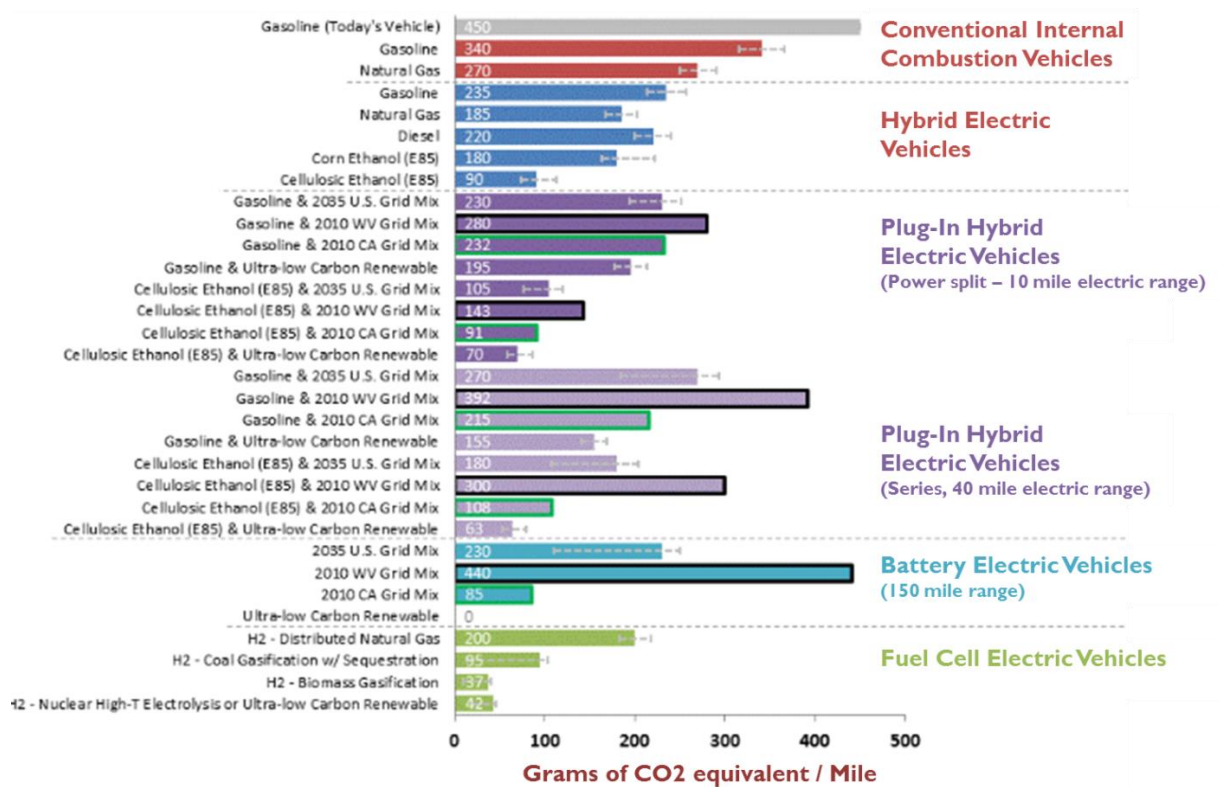
The dominant ULEV technology to currently penetrate the marketplace is hybrid petrol-electric vehicles (considered on p.247), however, there are a wide range of technologies under the general label of ULEVs, each a different technology solution to the same problem: carbon reduction.

There is ambiguity as to how an 'Ultra Low Emission Vehicle' would be defined. A range of technologies can help reduce vehicle emissions, and even very small conventional ICE vehicles have the potential to have "lower emissions" than a larger vehicle with a hybrid or electric drivetrain. For this reason, the thesis has taken a "relative" view of emissions, rather than considering ULEVs to produce emissions below a threshold in absolute terms. EVs and H<sub>2</sub> vehicle emissions are also dependent on the variable carbon content of electricity or hydrogen. This further complicates assessment of vehicle emissions.

Offer, Contestabile, Howey, Clague & Brandon (2011) argue that Fuel Cell Vehicles and Battery Electric Vehicles *'should not be regarded as antagonistic [...] but should be supported together.'* In their techno-economic analysis of future low-carbon transport strategies for the UK, they argue that *"a future decarbonised road transport system, there is need for both batteries and fuel cells, with different degrees of hybridisation depending on the car type/size considered."*

These vehicles have different technical potentials in performance and range terms; however, the metric that this thesis considers is carbon reduction. As noted on the previous page, it is challenging to assess carbon reductions when the "carbon input" required to produce a unit of electricity or a mole of hydrogen is not a constant.

A range of vehicle technologies are exhibited in Figure 67. This shows that, for electric and hydrogen vehicles, ultimate emissions are highly dependent on the electricity grid mix or hydrogen production method. This highlights the need for a parallel transition in energy generation.



**Figure 75 - A Range of Vehicle Technologies Conventional and ULEV compared by Grams of CO<sub>2</sub> equivalent / mile. (EERE, US DoE, 2011)**

The model of vehicle emissions takes three scenarios: CA, California Grid Mix [279g\* CO<sub>2</sub>e/kWh] denoted by green outline (with a high proportion of gas, renewables, and nuclear), WV, West Virginia Grid Mix [1554g\* CO<sub>2</sub>e / kWh] denoted by black outline (almost completely carbon intensive coal) and US Grid Mix (no outline), the U.S. average portfolio [611g\* CO<sub>2</sub>e / kWh]. To compare UK grid energy mix is between that of California and the US average, at 454g CO<sub>2</sub>e / kWh in 2010, an improvement on the 704g CO<sub>2</sub>e /kWh of 1990. (DECC / DEFRA, 2012, pp. Annex 3, p.14).

\*N.B. These figures were calculated by the author from the figures given by EPA (2012) for annual generation (MW) and CO<sub>2</sub>e emissions (tonnes).

Furthermore, the Hydrogen scenarios presented also provide different carbon intensities of hydrogen. Steam reformation of natural gas is the most carbon intensive method of hydrogen production. It is also presently the most common. Other options offered are for gasification biomass or of coal with sequestration of CO<sub>2</sub> and production of hydrogen by electrolysis of water with renewables or nuclear.

All of these vehicle technologies are in evidence in the UK context to varying degrees. Their market penetration is considered on page 247.

### 5.2.6 Charging / Refuelling Infrastructure

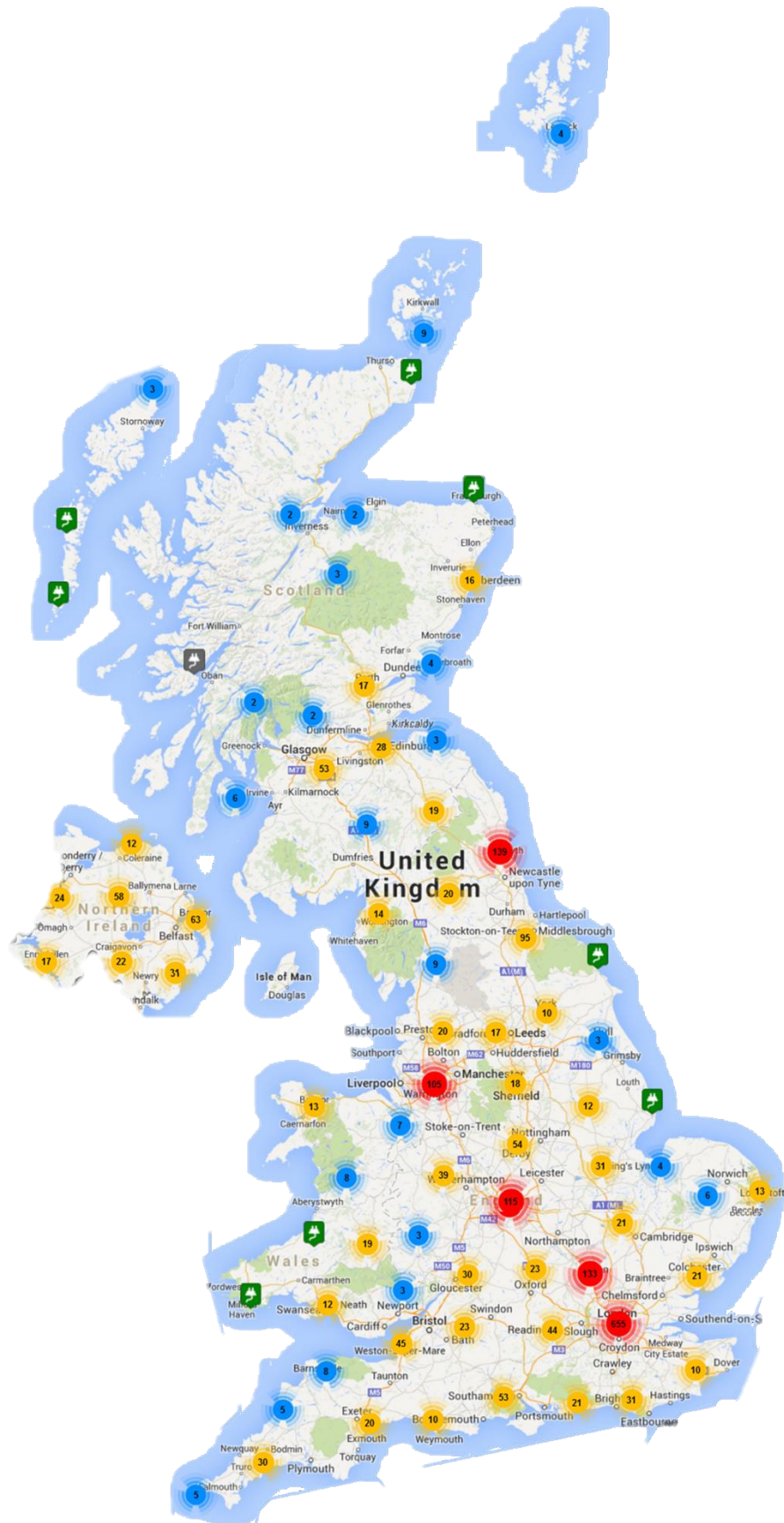
Melaina (2003) considers the 'chicken and egg' situation with respect to refuelling [and by extension charging] infrastructure. There is a reluctance to deploy infrastructure without sufficient vehicles deployed, yet there will be an unwillingness to purchase vehicles without existing infrastructure.

In the case study period, there has been significant progress in developing EV infrastructure in the UK. Estimates differ and are constantly being upwardly revised as to the number of electric vehicle charging points in the UK. As of November 2013, Open Charge Map (2013) pegs the number at 2405. There is now, to some degree, uniform UK coverage of EV charging infrastructure. Whilst it is not uniformly dense or convenient, all areas of the UK have EV charging points within EV range. It is particularly dense in those regions covered by the UK Plugged in Places scheme, which has focused on deploying early-market EV infrastructure. The UK distribution of charging points is illustrated in Figure 76.

Whilst travel using public charging points in rural areas may require careful planning, there are now sufficient points that journeys can be made to the remotest areas of the country with a little forethought. Some have taken to demonstrating this to the public to promote electric mobility (Llewellyn, 2014). Aside from publicly accessible charging infrastructure, given the ubiquity of the national grid, users may have private charging stations in rural areas.

Harper & Wells (2012) note that within the UK distinct regional narratives have emerged about the future trajectory of regional consortia and there is a diversity of narratives about the trajectory of technology development to support ULEVs in different locales.

Many see hydrogen and fuel cells as a technology for the longer term. At present, there are few opportunities for hydrogen refuelling. There are some limited small scale demonstration projects which offer hydrogen filling stations; however, few of these are open to the public. Furthermore, there have also been cases of hydrogen filling stations being closed. Hodson (2006) outlines the case of the hydrogen refuelling station in Hornchurch, which was closed after a barrage of local opposition on largely ill-founded grounds. The maps on the following pages illustrate current ULEV infrastructures.



**Figure 76 - Map Showing Distribution of UK Electric Vehicle Charging Infrastructure stitched together from (Open Charge Map, 2013)**



Figure 77 - Map Showing Distribution of UK Hydrogen Refuelling Infrastructure stitched together from (Ludwig-Bölkow-Systemtechnik GmbH and TÜV SÜD, 2014)

### 5.2.7 Potential Technological Fixes To Social Challenges

All ULEVs suffer from challenges of infrastructure. There are, however, some approaches that combine elements of technology and business model that could help to alleviate some consumers' reservations about ULEVs.

There are different approaches to vehicle charging. At its most basic, vehicle charging can take place from a standard 13A household socket, however, the power transfer is limited by the rating of the circuit (and the vehicle battery chargers ability to charge batteries quickly). Technology determines charging time. This presents a change in **VALUE PROPOSITION** from the experience consumers are used to with conventional vehicles where a full tank of petrol can be dispensed in minutes. There are a number of solutions to these social concerns; some of these are technical innovations, others business innovations, or a hybrid of the two but what they all have in common is the social goal of improving the usability of EVs so that they can potentially be made more acceptable.

#### 5.2.7.1 Battery Leasing

Battery leasing is an approach that becomes easier to implement where there is the possibility of removing the battery from the vehicle in a straightforward manner. *“The battery leasing business model is one proposed approach designed to reduce the initial capital cost and make the first electric vehicles directly competitive on the forecourt to ICEV.”* (Atkins Ltd, 2009). A number of interviewees mentioned a reluctance in the UK to engage with battery leasing models because of a culture of “ownership” in the UK. Martin Ward of CAP also commented that there was *“concern over how this would affect the residual price of vehicles: which would perhaps be of concern to fleet users”*. However, over the course of this study, this perspective may have softened. There appears to be growing recognition that battery rental business models have the potential to gain consumer acceptance and help overcome the anxiety about the high initial purchase price of EVs. Battery leasing rebalances the cost of ownership (Cherubinia, Iasevolib, & Michelinic, In Press), as there is a lower capital cost, but a rental charge for batteries spreading payments over time.



### **5.2.7.2 Battery Swap Infrastructure**

Battery Swap infrastructure comprises automated equipment that can remove batteries from a vehicle, and exchange them for freshly charged batteries rapidly. In the UK, there are no developed attempts to promote a 'battery swap' recharging infrastructure, unlike some other markets where a 'battery swap' business model is being pursued. (See Project Better Place, Page 170). The reasons articulated for this are many and varied. A range of interviewees from public bodies and regional development agencies commented on the culture of 'ownership' in the UK being hostile to leasing or renting batteries from a public bank. Furthermore, the clusters where battery swap infrastructure is being seriously considered tend to comprise small, densely populated geographies. That said, as the case studies reveal, there are a few manufacturers who have released vehicle solutions that allow for "battery swap", albeit manually (e.g. Modec p.346) and not in the automated manner envisaged with Project Better Place.

### **5.2.7.3 Fast Charging**

As a result, of the limitations of charging electric vehicles through traditional charging circuits, there have been moves to try and improve the electric vehicle charging experience through the development of faster charging. This involves battery charging systems that are able to transfer a greater amount of power to the vehicle. Tesla (2014) has addressed this through their "supercharger" technology, which is a physical wired connection that allows for a much greater rate of power transfer. Another competing standard is CHAdeMO, which has been developed by the Chademo Association (2014) in Japan and has been adopted by other vehicle manufacturers.

It will be interesting to see whether the industry continues to pursue a range of proprietary solutions or whether one solution emerges as dominant. "Format Wars" are well known (VHS vs. Betamax, HD-DVD vs. Blu-Ray etc.) and there are potential issues ahead with "path dependency" (p.49) and "technology lock in" (p.50) if one proprietary standard establishes an early lead over the others.

#### ***5.2.7.4 Inductive Power Transfer***

Another technology which threatens the Project Better Place hot-swap recharging business model is 'inductive power transfer' (Sunderland, 2010). Whilst this still requires a long-cycle to charge the batteries in the vehicle, the power is transferred wirelessly, adding user convenience and reducing the perception that charging has to be an inconvenience. In the UK, there have been some small scale field trials of an implementation of this technology developed by Qualcomm (Nagra, 2012). The manufacturers have claimed that there is only a small efficiency penalty with the technology and that it is as fast as conventional charging.

#### ***5.2.7.5 'Apps' for Vehicle Charging***

As previously noted, one of the major barriers to EV adoption is public concern regarding the ability to charge electric vehicles. It is possible to use software to provide reassurance to users and there is intense research activity to develop a variety of "apps" (Campolo, Molinaro, Paratore, & Ruggeri, 2012) which can run on mobile devices that may help to counter questions of "range anxiety" and concern over the ability to find charging points. Furthermore, Apps can connect wirelessly with vehicles allowing the "state of charge" to be viewed without having to be inside the vehicle, which provides reassurance to the user and helps to alleviate some of the anxieties of battery life. Whilst a paucity of charging points might be a concern to some users, smart 'Apps' that allow charging points to be located but also provide feedback on whether they are available or not are another tool that can help to tackle user confidence issues about the switch to EV.

One of the things that emerged from the interviews with One North East was the experience from their trials revealed that "more signposts than charging points" were necessary in order to counter user anxiety and apprehension over where to charge their vehicles. Once again, Apps provide for electronic "signposting" of EV charging points. It is a theme in the literature that information and communication technologies have enabled many business models that would be otherwise impossible to implement. Given the growth of ICTs it is reasonable to pre-suppose that this will unlock other business model innovations in the future.

### 5.3 An Economic Perspective on the UK Motor Industry

The UK Automotive industry adds £9.5 billion annually to the economy (DfT, 2009), comprising 0.8% of the UK economy. The industry also produces 13% of the UK's manufactured exports.

Historically, vehicle production was regarded as important to the “balance of trade”. However, as the UK motor industry began to enter a period of decline, the UK from 1976 began to import more cars than it exported. There are recent signs that this trend may be reversing as, in the first quarter of 2012, the UK reported its first trade surplus in passenger vehicles (Maer, 2012) in just over a third of a century. However, to understand the economic context and expectations of the UK car industry, it is necessary to contextualise current developments against the economic history of the UK car industry.

Cooke (2009) notes that in recent memory the UK has been the second largest global manufacturer of vehicles and the largest exporter of vehicles. By 2009, around the time that work on this thesis had begun, the position had slipped to the twelfth largest global manufacturer of vehicles (Cooke, 2009) and the industry was suffering from one of the largest “*collapse in sales and manufacturing greater than any other period in peacetime*” (Cooke, 2009). However, in more recent years, the industry has made a dramatic recovery, with vehicle manufacturing returning to 2007 pre-recession levels (BIS, 2014).

In the early days of the UK car industry, there were a large number of domestic manufacturers. Initial foreign investment in the UK motor industry came from America. General Motors. Ford established ‘Ford of Britain’ and expanded dramatically in 1932 when it opened its factory in Dagenham, London.

In 1952, the British Motor Company (BMC) was formed from the merger of Austin and Morris. Later, BMC acquired “Pressed Steel Bodies”, who supplied bodywork to BMC and also to Jaguar Cars. One year later they acquired Jaguar Cars and changed the name of the company to British Motor Holdings. The 1960's marked a period of increasing government intervention in managing the economy. Labour had published its “National Plan” in 1965 (Dunnett, 2013, p. 87). In 1968, it merged with Leyland

Motor Corporation who were nationalised to form British Leyland Corporation. Later in 1986, it changed its name to Rover Group.

Whilst the domestic champion was in decline, the 1980's marked a renaissance for the British Car Industry, with new methods, investment and expertise from Japan. Chapter 3 covers the Japanisation of the Motor Industry's business model (see p.129). In the UK this took the form of Honda establishing a manufacturing engineering joint venture with Rover Group in 1982. Nissan Motor Manufacturing UK opened their plant in Washington, UK in 1986 (Nissan, 2014) with Toyota Motor Manufacturing of the UK following in 1989 (Toyota, 2014). Furthermore, the methods of Japanese car manufacturers began to transform the practices and processes of car manufacturers around the world.

Recently, automakers in the developed world have had their business model challenged. Poor demand has resulted in overcapacity. This has particularly affected the middle of the market, (Knudsen, Randel, & Rugholm, 2005, p. 6) a process termed '*market polarisation*'.

Intense price competition from firms making products in low cost Eastern Europe has seen the rise of brands like Skoda and Dacia who now offer quality at very competitive prices. Furthermore, Korean firms like Hyundai and Kia provide offerings that compete strongly on price. Whilst there has been some migration from the middle market to the value end of the market, this has been accompanied by a more significant shift from the mid-market to higher end luxury product offerings.

The UK has been well placed to capitalise on this growth in premium products. The home to a great many historic brands, BMW has taken the 'MINI' brand upmarket from a utilitarian car for all people to a premium compact vehicle. Jaguar Land Rover, now owned by Tata, continues to make high end vehicles. More recently, the UK has been renowned for its premium home-grown marques, however, many of these have benefited from the investment and expertise that has come from foreign ownership.

### 5.3.1 UK Vehicle Production

The historical account on the previous pages frames the following graph, which illustrates the historical vehicle production of the UK motor industry. The peak of car production in the UK was in 1972 (Maer, 2012, p. 3) with the industry then entering a period of rapid decline. It was only after foreign investment from the 1980's onwards (Maer, 2012, p. 3), largely from Japanese manufacturers, that the numbers of UK produced vehicles began to recover through the 1980's and 1990's.

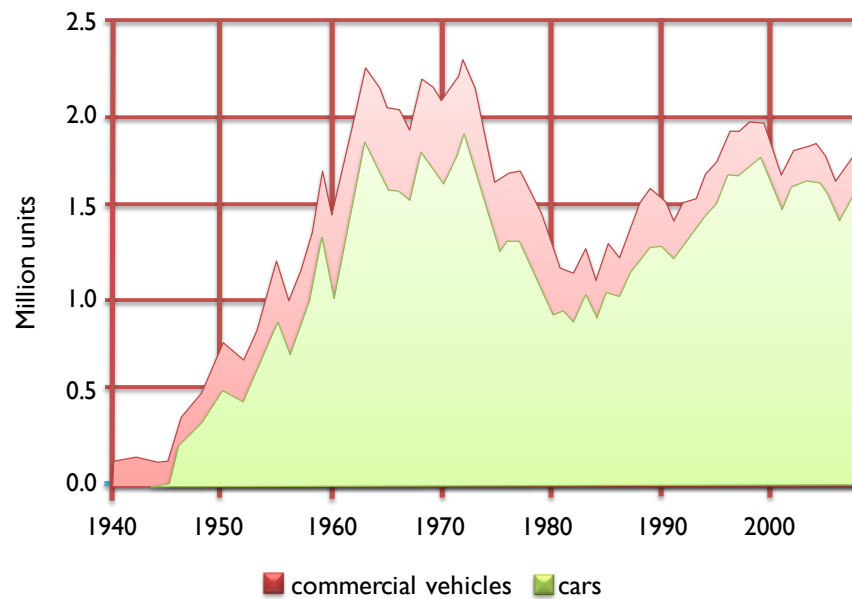
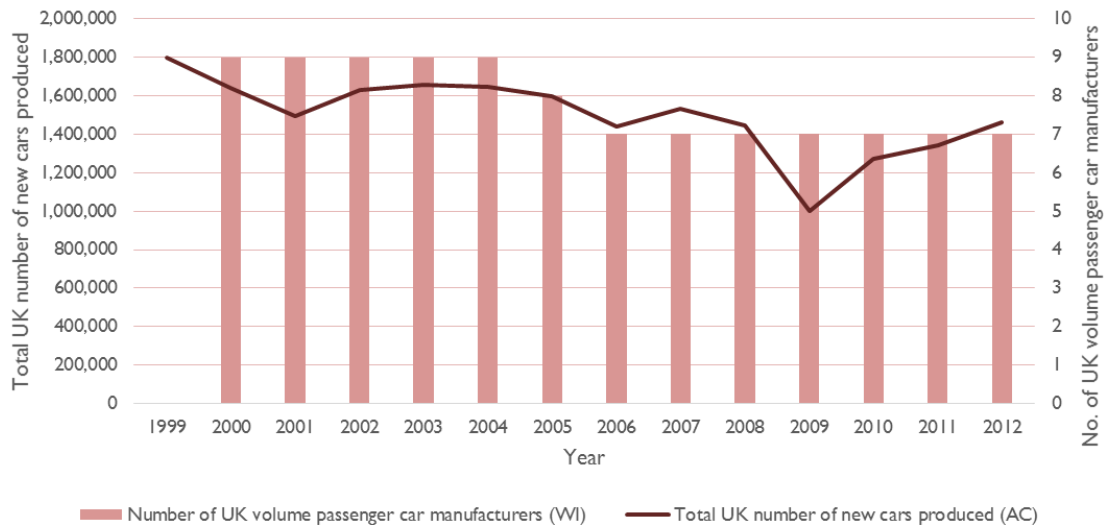


Figure 78 - UK Vehicle Output 1940-2008 Redrawn from (Holweg, 2009, p. 16)

To take a closer look at more recent events; in the past decade, there have been two very significant events that have shaped the landscape of UK vehicle production: the recession and the closure of Rover, which marked the end of an indigenous British volume vehicle manufacturer.

In Figure 79, the impact of the recession can be keenly perceived, with the output of UK vehicle manufacturers dropping from 1.75 million vehicles to 1.09 million vehicles (Maer, 2012). In 2008, vehicle production fell by -5.8%, 2009 was even more pronounced with a drop in production of -33.9%. However, by 2010 and 2011, vehicle manufacturing had begun to recover with increases of 27.8% and 5.1% respectively.



**Figure 79 - UK Vehicle Production & No. of UK Volume Vehicle Manufacturers**

That said, the recession was not bad for all manufacturers, and in fact acted for some as a catalyst for change. In summarising its effect on Nissan, Andy Palmer, Senior Vice President of Nissan Motor Company, suggested that the global financial crisis in fact has positive effects for Nissan, who at the time were developing the Leaf electric vehicle, as government stimulus for the automotive industry was channelled into ‘green’ projects, which benefited their electric vehicles programme.

***If we had had to fund those battery plants from normal operations the cadence of product roll-outs would have been much slower. So I actually think that viewed from my side, the electric vehicle business benefitted from the crisis. We did not cut one line of investment on electric vehicles throughout the crisis.***

**Andy Palmer, Senior Vice President of Nissan Motor Company (AWPresenter, 2010b)**

None of the remaining volume manufacturers of vehicles in the UK are UK owned. Rhys (2000, p. 5) “the future of car making in the UK is inexorably bound up with the prosperity of companies over which we have no effective control”. However, there are seven foreign-owned mass car manufacturers in the UK (Maer, 2012, p. 4). The UK now “has a more diverse ownership of its vehicle manufacturing than any other nation” (Cooke, *The United Kingdom Automotive Industries: Status, Economic Recovery & Expectations: A Report for the SMMT, 2011*).

### 5.3.2 Automotive Sector Employment Trends

In addition to supporting jobs as part of vehicle manufacture, the UK automotive industry also supports jobs in key partners of vehicle manufacturers, namely component and module suppliers. The automotive industry represents 0.6% of UK employment (DfT, 2009). It is estimated that every job in UK vehicle manufacture supports 7.5 jobs elsewhere in functions that support the car industry (Maer, 2012, p. 3). There are 146,000 jobs (SMMT, 2014) supported by vehicle manufacture. Moreover, there are an additional 737,000 jobs (SMMT, 2014, p. 1) supported directly as a result of vehicle manufacture in allied companies. The automotive industry also supports other manufacturing industries supporting 200,000 jobs in allied manufacturing operations (DfT, 2009). There is also a strong regional dimension to motor industry employment; in the West Midlands, the traditional heartland of the automotive industry, it accounts for 1.5% of employment and in the North East the figure is 1.1%. This compares with an average of providing 0.5% in the UK economy as an average, and by contrast in London, the industry accounts for 0.1% of employment (Maer, 2012, p. 3).

One of the factors that make the UK particularly popular as a destination for car manufacturers is its labour flexibility (see figures on p.244). The longer term decline of the UK automotive industry has been mirrored by a decline in employment in the industry. This should be viewed as part of a wider trend, with jobs shifting from 'high cost' labour countries in the west of Europe to lower cost countries in Eastern Europe. Figure 80 shows the situation in the years leading up to the conduct of this case study research, with jobs in the UK car industry declining the most compared to a number of other European Union countries.

However, there are some factors that are considered a disadvantage for basing manufacture in the UK, related to the perceived availability of skills and a skilled workforce. That said, ULEVs, will require a new skills base and initiatives, such as those between Nissan & Gateshead College, show how creative engagement by manufacturers can upgrade skills locally. Secondly, the availability of component suppliers rates highly amongst concerns, this is particularly a concern given that offshoring has hollowed out the UK's manufacturing capability; that said there are signs that this trend may reverse.

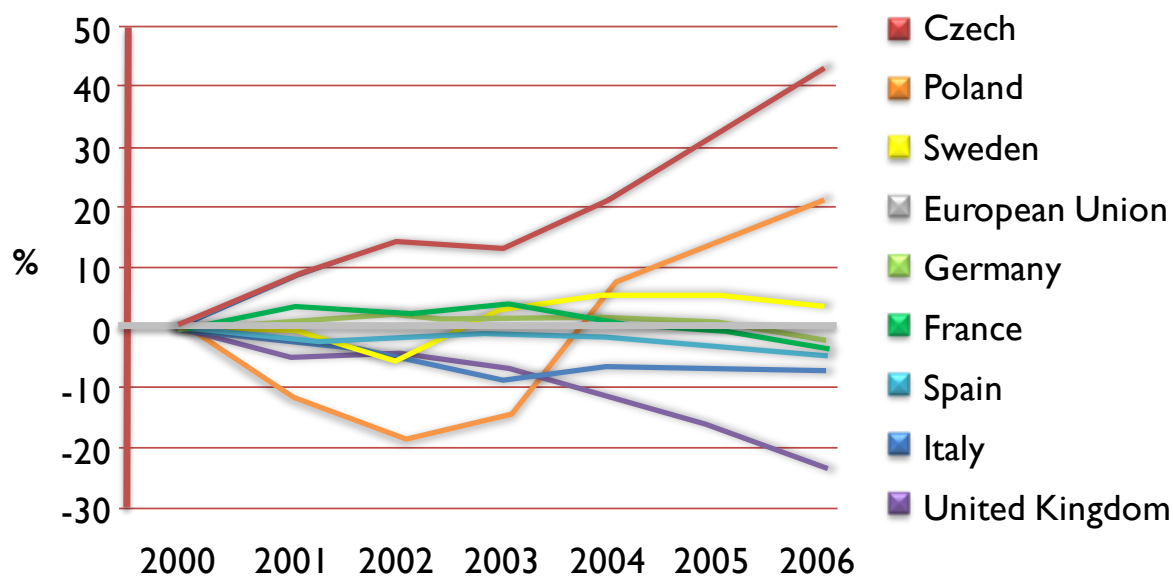


Figure 80 - Automotive sector employment trends indexed against a 2000 baseline. Image redrawn from: (Holweg, 2009)

Criteria	France Germany Italy Spain	United Kingdom	Difference	Degree of Relative Advantage
Labour flexibility	2.13	3.94	-1.81	<b>Relative Advantage for the UK</b>
Barriers to exit	1.92	3.29	-1.37	
Taxes and Tariffs	3.23	3.27	-0.04	
Labour productivity	3.19	3.06	0.13	<b>Relative Disadvantage for the UK</b>
Interaction with government	3.44	3.18	0.26	
Labour cost	2.38	1.94	0.44	
Logistics and Infrastructure	3.47	2.88	0.59	
Government subsidies	3.92	3.31	0.61	
Environmental regulation	3.14	2.44	0.70	
Quality of R&D Resources	4.43	3.71	0.72	
Quality of local suppliers	4.00	3.00	1.00	
Availability of skilled labour	3.50	2.41	1.09	
Skill level of workforce	3.88	2.76	1.12	
Availability of local suppliers	4.00	2.53	1.47	

Figure 81 - Industry Leaders' perception of the UK's relative strength vs. France, Germany, Italy & Spain (Holweg, 2009)



### 5.3.3 Investment in Knowledge, Research & Development

Another challenge for the UK car industry has been investment in the knowledge required to update processes. The UK automotive industry invests £1.7 billion a year in research and development (SMMT, 2014). As Holweg (2009) identified, lack of research and development resource, was one of the factors perceived by car industry leaders as a relative disadvantage for the UK as a location (as illustrated on the previous page Figure 81). Figure 82 shows, how as a percentage of Gross Value Added, Germany, France and Italy have invested to a greater degree in research and development. The cumulative effect of this greater investment is a stronger R&D resource in these countries.

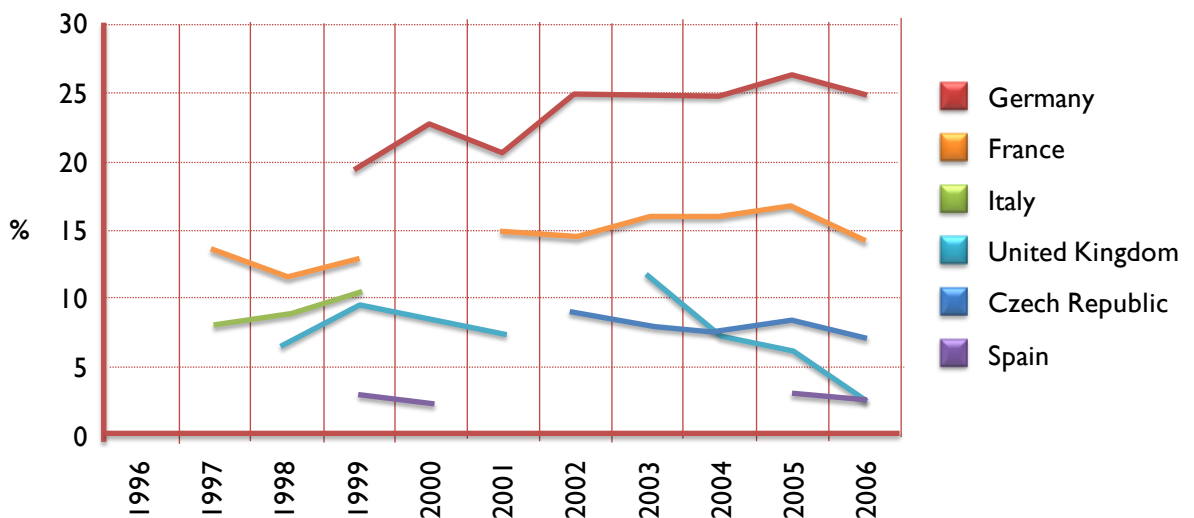


Figure 82 - Research and development expenditure in the motor vehicle industry (DM34) as a percentage of Gross Value Added (in DM34) – Redrawn from: (Holweg, 2009, p. 19)

As can be seen in Figure 81, the lack of Research and Development spend directly translates into perception of a 'relative disadvantage' of the UK as a location. In Figure 75, it can be shown that a cross section of industry leaders perceive the UK's lack of Quality R&D resources as a disadvantage when compared to France, Germany, Italy and Spain. That said the UK automotive industry does benefit from the R&D investments made in those other European nations. BMW's MINI and Rolls Royce marques (See page 271) are both produced in the UK and benefit from BMW's investment, whilst Nissan in Sunderland (See page 289) benefits from the R&D investments of the Renault-Nissan alliance in both France and Japan.

### 5.3.4 The UK in the International Marketplace

Despite its small land mass, the high wealth of the UK combined with a high level of motorisation means the country is still a significant marketplace for vehicle manufacturers as illustrated in Table 18.

<b>China</b>	14,472,400
<b>EU27</b>	13,111,209
<b>USA</b>	6,089,421
<b>Japan</b>	3,524,789
<b>Germany</b>	3,173,634
<b>Russia</b>	2,653,498
<b>France</b>	2,204,229
<b>India</b>	1,946,373
<b>UK</b>	1,941,253
<b>Italy</b>	1,748,143

**Table 18 - The UK as an international market - New car registrations in 2011 (SMMT, 2012)**

That said, of even greater strategic significance is the UK's position in regards to access to the EU market, which is much greater than the domestic market.

Whilst Britain retains the pound, it enjoys good access to the European market and integration with Europe as part of the European Union. Approximately four in every ten cars produced in the UK are shipped to the European Union (Foy, 2014), however, the Eurozone has experienced a profound crisis and sluggish recovery. Samuel Tombs, a UK economist at Capital stated that *“until the euro-zone economy experiences a robust recovery, the prospects for exports will remain dismal”*. Aldrick (2012) commented that the two main tools to ease the UK out of recession were low interest rates and the relative weakness of the pound. However, the pound has gathered strength against the Euro, which has been problematic from the point of view of exports to the Eurozone. As a result of poor Eurozone demand and a weaker pound against the dollar, more growth is coming from emerging markets (Aldrick, 2012).

### 5.3.5 Registration of Alternative Fuelled Vehicles

In Section 1.2, (page 38), OLEV's definition of ULEV was advanced as vehicles emitting  $>75\text{g}/\text{CO}_2/\text{km}$ . Alternative fuelled vehicles, are not necessarily ULEV's, however, alternative drivetrains are one route to lowering vehicle emissions through less carbon intensive fuels and energy vectors.

There has been steady growth in the registration of alternative drivetrain vehicles. The bulk of this growth has been in petrol-electric hybrid cars; however, since 2010, there have been signs of a growing market in electric vehicles, plug-in hybrid, petrol/alcohol dual fuel vehicles and diesel electric hybrid cars. However, they still only represent a small fraction of vehicles sold. These figures are illustrated below in Figure 83. From these figures, it can be seen that these vehicles are still in the minority considering UK annual vehicle registrations which hovers around the 2 million mark (Maer, 2012, p. 5).

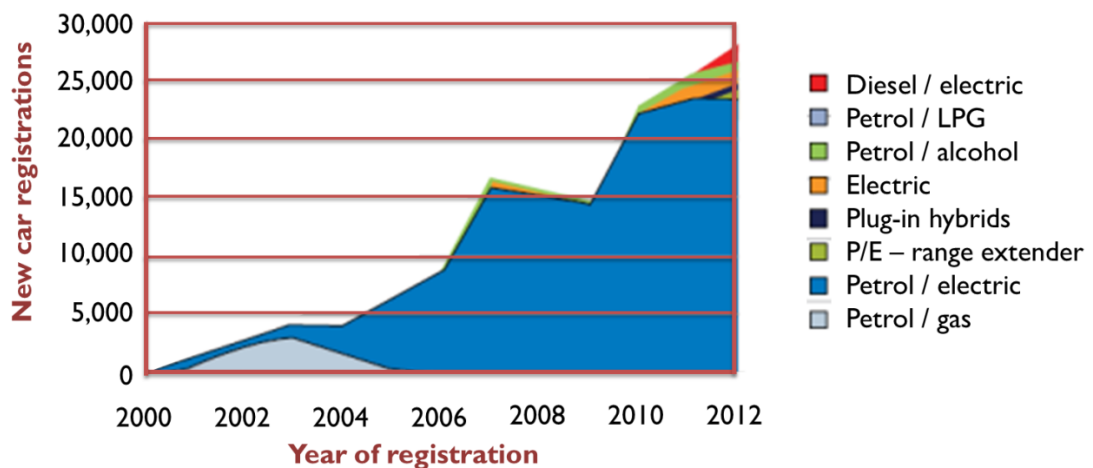


Figure 83 - Growth in Registration of Alternative Drivetrain Vehicles, Source SMMT

Whilst sales of hybrid vehicles comprise the largest part of ULEV sales in the figure above, more recent statistics appear to indicate that EV sales are also starting to gather pace. Since the launch of the plug-in car grant in 2011, there have been 7,495 cars registered under the scheme as of February 2014 according to the SMMT (2014). Some individual manufacturers such as Renault-Nissan have admitted that EV sales have been more sluggish than their initial predictions and that they have missed their own internal sales targets (Vaughan, 2013).

However, industry leaders are buoyant about the prospects for electric vehicles. Ian Robertson, Global Marketing Chief of BMW has said that "If you look back over the past three years, the electric car market has multiplied by a factor of 25," (Leggett T, 2014). Given that the fraction of the market ULEV comprise is small, understanding the early market dynamics is challenging, however, more recent figures show some promise that uptake of EVs is beginning to accelerate.

### 5.3.6 ULEV Sales in International Contexts

EV sales, and more specifically, EV sales as a percentage of new vehicle sales, is ultimately the indicator of whether customers in those markets are being encouraged to transition.

In this respect, the proportion of new car sales that Electric Vehicles represent in the UK (0.11% in 2012) is unexceptional compared to a range of other markets. To understand why the UK is unexceptional, it must be juxtaposed against other markets where there has been more comprehensive political support for ULEVs, resulting in a greater uptake of vehicles.

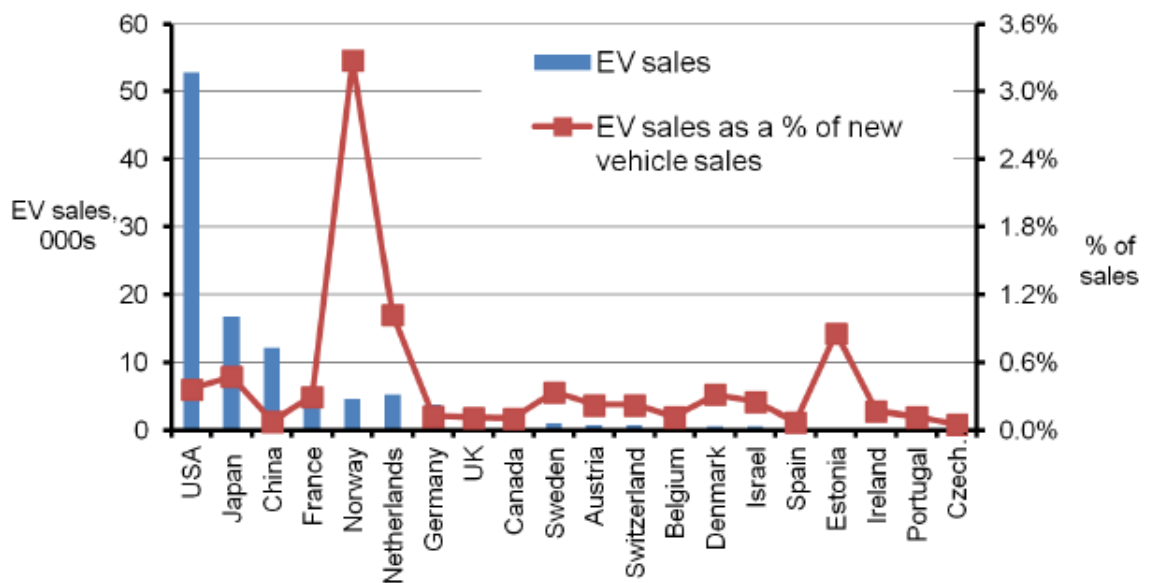


Figure 84 - EV Sales in a range of International Contexts reprinted from Element Energy (2013, p.25)

For contrast, one country, Norway, stands head and shoulders above the rest with electric vehicle sales representing 3.3% of all new car sales (Element Energy, 2013, p.25). There have been significant political interventions that can explain Norway’s success in this respect. A package of capital incentives introduced early-on provided an incentive that was worth up to £12,200 to Norwegian EV consumers (Element Energy, 2013, p.41). However, financial incentives alone cannot explain the switch of consumers to EV’s. To illustrate this, Element Energy (2013, p.43) cites the case of Denmark, who despite even greater financial incentives than Norway, still has a relatively poor penetration of EVs.

### 5.3.7 Plug-In Car Grant Uptake

The Office for Low Emission Vehicles has made a grant available to purchasers of Plug-In Vehicles of £5000. The grant aims to overcome some of the economic disincentive for consumers to purchase the first tranche of plug-in vehicles. In doing so, it incentivises manufacturers to introduce plug-in ULEVs. The uptake of this grant provides a closer view of the recent market growth in plug-in vehicles.

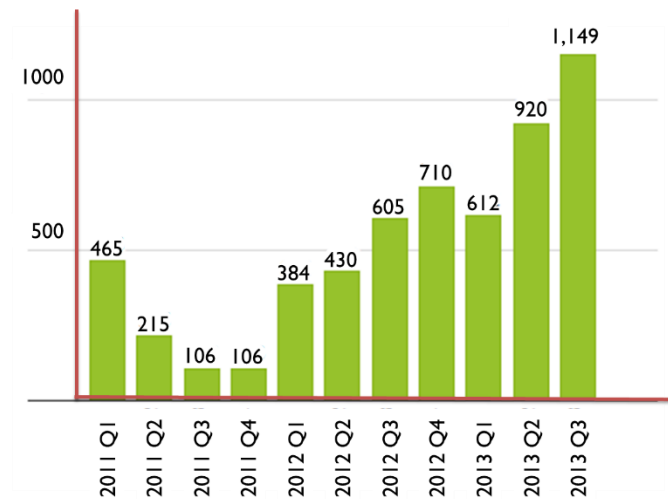


Figure 85 - Plug In Vehicle Grant Update (Vaughan, 2013)

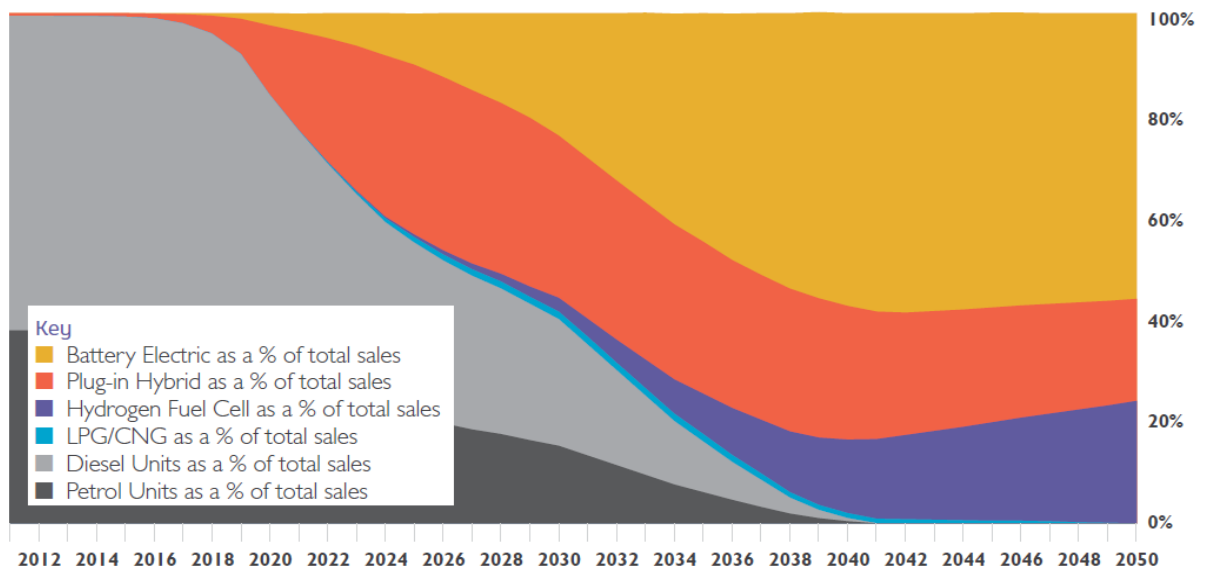
However, demand has been lower than forecast by the government. The scheme ends in 2015, by which point the Government estimates that it will have underspent by £170,000, around half of the initial £400 million allocated to support the introduction of plug-in vehicles (Vaughan, 2013). The current grant arrangements will be discontinued; however, the government has said that it will continue to provide economic incentives for the purchase of electric vehicles in the period 2015-2020.

The initial forecasts were that the budget allocated would have supported the introduction of 80,000 vehicles to the marketplace. However, based on current data, the projections are that only 46,000 vehicles will have been supported under the scheme (Sunderland, 2014). Roads minister Rob Goodwill commented that: “Sales of ultra low emission vehicles have been increasing year on year, but at a slower rate than originally anticipated.” (Yau, 2014)

### 5.3.8 ULEV Market Growth Projections

Predictions for the growth of the ULEV marketplace differ. These predictions are often made in tandem with technology roadmaps which forecast how the industry plans to bring technologies to the marketplace. Predictions rely on unknowns. There is a great uncertainty and technology forecasts are notoriously inaccurate. These factors have been discussed in the literature review on innovation.

As a near-term target, 2020 is a date around which many short-term predictions appear to revolve. Based on a review of the literature, Ricardo-AEA surmised “given an expected reduction in technology costs, EVs should be cost-effective against carbon price in the 2020s” (Element Energy, 2013, p.2). Dr. Wolfgang Bernhart predicts that ultra-low emissions vehicles could occupy 20% of vehicle sales by 2020 (AWPresenter, 2010d). Another estimate is provided by Boston Consulting Group (2010) present a range of scenarios, for 2020; In the ‘most likely’ prediction, they estimate that 26% of the new vehicles sold in the major developed markets (China, Japan, the United States, and Western Europe) will be ultra-low emission vehicles based on electric or hybrid drivetrains.



**Figure 86 - Outlook for New Car Sales in Scotland according to Transport Scotland (2013, p. 13)**

The following market predictions are based on a technology roadmap (see page 230) from Transport Scotland (2013, p.13) and is profound in both its scope and ambition and is indicative of a range of different outlooks and projections of how the new car market might look in the years ahead. If it

proves to be accurate, in less than a quarter of a century, by 2041, the dominant technology that the motor industry has relied on for over 100 years - vehicles powered solely by the internal combustion engine – will be completely displaced in favour of a technology mix of largely battery electric vehicles. The remainder will be divided between hydrogen vehicles with a slightly larger proportion of vehicles (around a quarter) being plug-in hybrid vehicles (with an ICE in some form).

Scotland has its own devolved Parliament, and so it should be borne in mind that the local political context and legislature influences Transport Scotland's perspective. However, this roadmap is significant as Scotland remains part of the UK context and so whilst technological foresight is notoriously difficult, it provides an indication of one potential future scenario for part of the UK.

To contextualise this massive change in the industry, a Janus-like perspective looking forty years into the past shows us that the UK car industry has been capable of dramatic transformation and radical change and reconfiguration. Considering how with the fall of indigenous champions, investment by Japanese car makers, and foreign regeneration of British the UK industry has completely changed, it is not inconceivable that in forty years hence other profound and sweeping changes will occur.

It is also a political objective to encourage the growth of ULEVs. However, in order to achieve this objective there is a need for consumers to engage with ULEVs (Element Energy, 2013, p.2).

Element Energy (2013, p.5) considered the aggregated targets of fourteen countries in the respect of electric vehicles. To contextualise the targets should VMs reach them, they would still only represent 7% of industry output. They note that in order to achieve these aggregated targets, there would need to be a consistent increase in EV production capacity by 30% every year, post 2015 until 2020.

In some respects this sounds ambitious, yet Element Energy (2013, p.5) note that there is already spare production capacity. Furthermore, many EVs are based on existing production vehicles, rather than bespoke EV platforms, and so in this context, the targets are quite achievable.

## 5.4 The UK Political Context for ULEVs

This section evaluates the political contextual factors that shape both the UK transport regime and those that act within it. It takes the approach of looking at political factors on different scales: continental, national, regional and local. Meadowcroft (2011, p. 70) has highlighted that the political dimension of sustainable transitions has been neglected in scholarship, noting that (2011, p. 71) *“Politics is the constant companion of socio-technical transitions, serving alternatively (and often simultaneously) as context, arena, obstacle, enabler, arbiter, and manager of repercussions.”*

Perhaps the single biggest factor that has shaped the political narrative over the period of investigation is the global recession, which in turn prompted a global automotive industry crisis and the ensuing political responses to these crises. Economic events have created a backdrop for political change and have shaped the political landscape. Environmental issues that were beginning to creep up the political agenda have been cast aside (Spencer, 2012). Rebuilding the economy the central issue; yet under the cloak of economic growth, right-wing politicians have managed to shape the political landscape in ways that have re-enforced the power of elites and incumbents (Sullivan, 2013; Seymour 2012, 2014).

The global automotive industry crisis seemingly affected ULEV sales at the same time as traditional vehicle sales. Vaughan (2010) notes the general challenges surrounding selling vehicles in the recession, the global slump, whilst affecting new car registrations (only 2 million new registrations in 2009 – the lowest figure since 1995) was felt even more greatly by electric vehicles, where the decline in sales was eight times greater than for traditional vehicle sales. The Society of Motor Manufacturers and Traders noted that sales of electric vehicle declined from 397 new registrations in 2007 to 55 in 2009 (Vaughan, 2010). However, there is also a tale of recovery; whilst there may be slightly less emphasis on environmental policy on the whole, the UK’s significant sunk investments in ULEVs have ensured that with strong political pressure to rebalance the economy away from financial services to manufacturing (Civitas, 2013). There is a need to consider the regional dimension to the UK economy to ensure that growth is not just concentrated in the South East (Groom, 2013). There is strong political support for UK vehicle manufacturers and businesses that have the capability to export products.



### 5.4.1 UK Government Sustainable Development Policy

A definition of 'sustainable development' specific to UK transportation was advanced by the then Department of the Environment, Transport and the Regions (1998) who use the following criteria:

1. *“Social progress which recognises the needs of everyone;*
2. *Effective protection of the environment, limiting global effects;*
3. *Prudent use of natural resources; and*
4. *Maintenance of high and stable levels of economic growth and employment.”*

This resonates with the stance taken by this thesis of 'soft' sustainability expanded on p.5.

The Climate Change Act 2008 (c.27) makes it a duty of the Secretary of State to reduce emissions of Carbon dioxide, methane, nitrous oxide and sulphur hexafluoride, hydrofluorocarbons and perfluorocarbons. The act sets a legally binding target of an 80% cut in emissions in these pollutants by 2050, with an intermediate target of reducing emissions by 34% by 2020 against a 1990 baseline. The act extends throughout the UK; however, the devolved governments of Scotland and Wales also have responses to Climate Change (the Climate Change (Scotland) Act 2009).

Before the last government, the Conservatives came to power on a pledge to be the 'Greenest Government Ever', with slogans such as "Vote Blue, Go Green" (BBC, 2006). Having taken a trip to the arctic circle to view receding glaciers and delivering recycling boxes door to door, it appeared that David Cameron would take the Conservative party in a different direction (BBC, 2006). The Liberal Democrats also, historically, had supported green values. The coalition government has set its plans for carbon reduction out in its document, "The Carbon Plan", (Department of Energy & Climate Change, 2011). Within they cite how the spending review confirms the provision of £400 million in funding to support the ULEVs market.

Offer, Contestabile, Howey, Clague, & Brandon (2011) argue that aggressive pricing of carbon would increase the uptake of alternatively fuelled vehicles; however, attempts to price carbon are politically unpopular and there are significant challenges with implementation of such an approach. Given the change in policy direction by the coalition government, this seems increasingly unlikely in the near future. In a 'stop press' moment, Chancellor George Osborne (2014) froze the Carbon price floor at

£14/tonne CO<sub>2</sub> and capped the Carbon Price Support at £18/tonne from 2017-18 for the rest of the decade. The stated aim was to help medium size manufacturers. However, Murray (2014) noted that many analysts felt that this sent out mixed messages to those investing in green technologies. Murray (2014) also notes that the Budget speech made no note of the climate or green economy.

However, in another move, effectively a 'bonus/malus' on company car taxes, company car tax of 2% was extended (Osborne, 2014), whilst exemptions for low emission vehicles were increased.

#### **5.4.2 UK Transport Policy**

In what Hull (2005, p. 326) describes as "New Labour's Visionary Phase", transport shared a portfolio with Environment and Regional Issues, during which Hull (2005, p. 326) notes that there was a broadly co-ordinated approach to these interlinked issues. A turning point came in 2002, where these issues were disaggregated departmentally (Hull, 2005, p. 326).

The Department for Transport's low emission vehicle strategies are co-ordinated by the Office of Low Emission Vehicles (OLEV) (set up under the previous Labour government).

OLEV co-ordinates a number of schemes, such as the "Plugged In Places" scheme. This is an incubator project to establish free-of charge electric vehicle infrastructure. The first round was won by three UK locations: London (the capital), Milton Keynes (a new-town designed in the Sixties in a manner that was particularly car-centric) and the North East (home of Nissan, manufacturer of a third of UK-produced vehicles, who have recently announced a number of investments in the area relating to the production of battery electric vehicles).

OLEV are also offering a consumer grant for ULEVs which will cover 25% of the purchase price of an 'ultra-low / zero carbon vehicle' up to £5,000. Sunderland (2013) notes that the effectiveness of the grant in increasing EV uptake has been questioned.

### 5.4.3 UK Regional Governance

The coming of devolution to Scotland, Wales and Northern Ireland combined with the London Assembly and election of a Mayor of London ushered in a new era of decentralised decision making within the UK. Within England, under the previous 'New Labour' government, regional autonomy was created through a number of regional structures. Since then profound political changes to regional governance (that have impacted upon the regime) have been introduced by the coalition government. Harper & Wells (2012) have noted that there is diversity in regional approaches to ULEVs.

Regional Development Agencies (RDA's) were a project of the Labour government. Initiated under the Regional Development Agencies Act 1998, these agencies were instrumental in channelling public funds into a number of start-up projects in the regions. Their aim was to assist in rebalancing the geographical distribution of economic growth by working on projects to develop regional economies.

In the sphere of ULEVs, RDA's made significant inroads to advancing the cause of ULEVs as a motor for regional growth, implementing a diversity of solutions in different regions (Harper & Wells, 2012). Perhaps most significantly in the North East of England, ONE (One North East) played a significant role in securing the regions 'Plugged in Places' bid and winning the support of Nissan for a battery assembly plant (covered more extensively on p.289). These RDAs were in turn replaced by the coalition by Local Enterprise Partnerships (LEP's) (Bentley, Bailey, & Shutt, 2010). Whilst the political rhetoric claimed that LEPs were a "localisation" of power, Bentley Bailey & Shutt (2010, p. 535) argue that LEPs were in fact "*profoundly anti-regionalist*" and "*re-centralisation in disguise*". Furthermore, the pot that LEPs have to 'bid into' is a quarter of the size of the funding provided to RDAs (Bailey, 2010).

This narrative has been echoed by Stafford & Ayers (2013) who note that the previous Labour government had built up regional capability for decentralised transport decision making. This permitted a degree of autonomous decision making at the sub-national level. Through 'regional funding allocations' in 2005 and 2008, regional intelligence was intended to support national decision making (Stafford & Ayers, 2013, p. 135). The coalition's approach has been described as "post-regionalist", with an emphasis on localism (Stafford & Ayers, 2013, p. 134).

#### 5.4.4 UK & the European Union

The European Union (EU) is the second biggest market for cars and is therefore significant when considering the economic context for locating manufacturing in the UK. The political consensus about EU membership, however, has been increasingly eroded by vocal politicians.

In some sections of British society, there has been a rise in Euro-scepticism, with the issue attracting increasing attention with the challenges to the Eurozone economy (Landale, 2013). There is a significant block of Conservatives who are sceptical of the UK's continued membership of the EU (Stourton, 2013). The United Kingdom Independence Party (UKIP) is a right wing political party which have grown in prominence in UK politics. One narrative is that the Conservative Party, under David Cameron's leadership, has moved incrementally towards the centre-ground. This has alienated some on the far right of the party who have been pushing for Britain to have a referendum on whether to stay in the EU or leave. Using language that in many ways mirrors the language of transitions, Lynch & Whitaker (2013, p. 285) use concepts of "niche" vs. "mainstream" political parties to unpick the emerging political narrative that challenges Britain's membership of the EU. The Liberal Democrats (2014) have strongly defended Britain's continued membership of the EU managing to remain sanguine about Britain's role in Europe despite concerted opposition. Nick Clegg (2014) challenged Nigel Farage to a televised debate on the issue. However, the Labour Party have been more non-committal, with Ed Miliband saying that a referendum on Europe was "unlikely" (Robinson, 2014).

This has created instability and concern in industry. It was revealed in the interviews with several of the large VMs that, when decisions were taken about where to locate manufacturing capacity, one of the UK's strong selling points (along with its high labour productivity) was its access to European markets. Carlos Ghosn, the head of Nissan, has warned that the car maker may consider leaving the UK were it to exit the European Union saying *"If anything has to change we [would] need to reconsider our strategy and our investments for the future"*. (Press Association, 2013). A number of carmakers added their voices to this call, including Ford (Bennett, 2014<sub>a</sub>) and Hyundai (Bennett, 2014<sub>b</sub>). Foy (2014) noted that the car industry has emerged as one of the most vocal critics of this EU indecision.

### 5.4.5 European Policy

The automotive sector accounts for 10% of European Union manufacturing value (Wengel, Warnke, & Lindbom, 2003, p. 2). At the turn of the millennium, one third of the global production of cars, 20 million passenger cars, were produced in Europe. In 1995, it was also the largest industry sector in employment terms, accounting for 1.2 million people manufacturing and assembling vehicles whilst over half a million people were employed manufacturing components for the automotive industry.

Being a member state of the European Union and subject to European policy impacts significantly on the UK context.

The European Commission (2011) has made a number of interventions to support the introduction of ULEVs. Specifically, it aims to promote the deployment of transport infrastructure through mandating common standards for recharging infrastructure. Furthermore, a European Commission whitepaper (2011) states a number of goals: *'halving the number of conventionally fuelled vehicles used in urban transport by 2030 with a total phase out by 2050 and achieving zero CO<sub>2</sub> logistics in cities by 2030'*. The European Union has a history of showing leadership as far as vehicle emissions are concerned, through the delivery and implementation of regulations and directives.

Another way that the European Union has sought to decarbonise Europe's transport system is through the European Union (2003) Directive on the Promotion of the use of biofuels and other renewable fuels for transport 2003/30/EC. The directive mandated that, by 31 December 2010, 5.75% of all fossil fuels should be replaced by biofuel alternatives, with an intermediate target of 2% by 31 December 2005. There has been significant criticism of this policy. Whilst the intention to improve sustainability through decarbonisation was laudable, many voices felt that many unintended environmental impacts would arise from a shift to biofuels (TNI, 2008; Royal Society, 2008). With the greater awareness of the impacts of biofuels, attention has shifted to alternative decarbonisation solutions including ULEVs.

### 5.4.6 Vehicle Emissions Standards

Conventional internal combustion engine vehicles, emit a cocktail of by products from their exhausts as a result of burning hydrocarbon fuels. These emissions vary depending on whether the fuel is, diesel, petrol, liquefied petroleum gas or compressed natural gas.

Vehicle emissions contribute to the global problem of anthropogenic climate change, but they also contribute to a local problem of air pollution and smog, which is particularly acute in urban areas.

The global problems result from vehicles' emissions of Carbon Dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O). The local emissions problems from automobility, result from emission of benzene, 1,3-butadiene, carbon monoxide (CO), nitrogen oxides (NO<sub>x</sub>) and particulates (PMs).

The response in the European Union to these emissions has been the rolling 'Euro Emissions Standards' a programme of emissions improvements, that tighten over time, encouraging manufacturers to improve the emissions of their vehicles.

Euro Standard	Implementation date*	CO (g/km)	THC (g/km)	NMHC (g/km)	NO <sub>x</sub> (g/km)	HC=NO <sub>x</sub> (g/km)	PM (g/km)
<b>Diesel</b>							
<b>Euro I</b>	July 1993	2.72	-	-	-	0.97	0.14
<b>Euro II</b>	January 1997	1.00	-	-	-	0.70	0.08
<b>Euro III</b>	January 2001	0.64	-	-	0.50	0.56	0.05
<b>Euro IV</b>	January 2006	0.50	-	-	0.25	0.30	0.025
<b>Euro V</b>	September 2010	0.500	-	-	0.180	0.230	0.005
<b>Euro VI</b>	September 2015	0.500	-	-	0.080	0.170	0.005
<b>Petrol</b>							
<b>Euro I</b>	July 1993	2.72	-	-	-	0.97	-
<b>Euro II</b>	January 1997	2.20	-	-	-	0.50	-
<b>Euro III</b>	January 2001	2.30	0.20	-	0.15	-	-
<b>Euro IV</b>	January 2006	1.00	0.10	-	0.08	-	-
<b>Euro V</b>	September 2010	1.000	0.100	0.068	0.060	-	0.005**
<b>Euro VI</b>	September 2015	0.100	0.100	0.068	0.060	-	0.005**

\* Market placement (or first registration) dates, after which all new engines placed on the market must meet the standard. EU emission standards also specify Type Approval dates (usually one year before the respective market placement dates) after which all newly type approved models must meet the standard.  
 \*\* Applies only to vehicles with direct injection engines.

Table 19 EU emissions standards for passenger cars

The motor vehicle industry's response to these emissions standards, had thus far been based upon the refinement of internal combustion engine technologies. In petrol vehicles this has been achieved with a migration towards fuel injection systems which provide more precise control over the stoichiometry of the fuel air charge, and through three-way catalytic converters. In diesel engines improvements have been gained through direct injection and diesel particulate filters.

There has been some concern that the test-cycle used does not reflect real-world driving conditions, and that this results in vehicle manufacturers engaging in "cycle beating" by tuning vehicles to respond to the test cycle rather than real world driving conditions (EFTE [European Federation for Transport and Environment] 2006).

Vidal (2013) has outlined a number of ways in which car makers can legally 'game' test cycles by making improvements to vehicles which do not reflect real world driving conditions. This perhaps goes some way to explaining how vehicle environmental performance in real life, has failed to meet the predicted reductions of emissions standards. Transport for London (2014, 4-5) identified that: "*One of the largest failings in legislation over recent years has been the inadequacy of the Euro emission standards to deliver the predicted emission reductions.*". There are additional pieces of legislations which are relevant to the regulation of UK vehicle emissions.

Europe introduced mandatory labelling of vehicle emissions to promote consumer choice. The system was thought to be confusing in the UK and so it was simplified to be "consumer friendly".

The EU has also set "average" fuel economy standards for new passenger cars. The target is initially 130g CO<sub>2</sub>/km (phased in between 2012-2015) to be reduced to 95g CO<sub>2</sub>/km in 2027. McKinsey & Co. (cited in Schwoerer, 2009a) have said that the only way manufacturers will reach this target is with plug in vehicles.

#### **5.4.6.1 Future Emissions Standards**

The Euro VI standards are yet to be brought into force and manufacturers are currently preparing for deployment of vehicle engines meeting Euro VI standards. However, some argue that there is scope for greater ambition. Wells, Nieuwenhuis, Nash & Fraser (2010) set out an analysis of a range of solutions, with the potential to bring vehicle emissions down to 80g/CO<sub>2</sub>/km by 2020. They consider four scenarios as pathways to emissions targets that are more ambitious than current legislation. Their four pathways are not entirely mutually exclusive, but present potential routes to improvement:

- 1.** Focusing on improving the efficiency of internal combustion engine vehicles through a range of different efficiency improvements.
- 2.** Looking at a greater proportion of electric vehicles in the vehicle mix.
- 3.** Vehicle performance reduction.
- 4.** Exploring the potential for encouraging consumers to shift 'down segments' to smaller vehicles.

In terms of these four scenarios, they single out (2) as being interesting, as it has the potential not only to meet this more ambitious emissions target, but there is also the potential for 'overshoot' in this scenario, this is the scenario that explicitly focuses on ULEVs. Furthermore, they note that increasing the penetration of electric vehicles in the UK vehicle mix, has the potential to create 'learning' for the industry, and to 'lock in' the car industry to potential future emissions improvements as they invest in the research and development of new technologies.

#### **5.4.6.2 Climate Change Legislation**

The Climate Change Act (2008) embodies the UK's commitment to reduce its greenhouse gas emissions by at least 80%, compared to 1990 levels, by 2050. This top level commitment makes it incumbent on the Secretary of State to ensure that the UK meets this commitment.



#### **5.4.6.3 Air Quality Legislation**

The limits for the concentration of pollutants in outside air, comes from Europe through the EU Ambient Air Quality Directive (2008/50/EC) In the UK context, this directive was brought into law by the Air Quality Standards Regulations 2010.

There has been concern that in a number of UK cities, the air quality is not commensurate with the levels of pollutants mandated in legislation. As a result of this, local actions have been established in order to try and manage urban air quality. An example of this regional legislation, which can act as a driver for clean vehicles in those locales, is the London Low Emission Zone.

#### **5.4.6.4 London Low Emission Zone**

The London Low Emissions Zone is interesting, as it is a 'regional' approach to regulating vehicle emissions. What is interesting about this sort of approach, is that major city regions could potentially be 'incubators' for ULEV technologies through tighter emissions standards. By introducing city emissions standards (rather than national emissions standards), the regulation is focused on the area where local pollution problems are the most acute; but also the concentration of wealth in cities, combined with a high penetration of public transport, means that cities are well equipped to respond to this legislation with innovative measures.

The London Low Emissions Zone (Transport for London, 2014: 20) covers lorries, buses, mini buses and coaches and covers the Greater London Area. There is an ambition to extend the scope of the 'Low Emission Zone' to become an 'Ultra Low Emission Zone' (ULEZ) in the future (Transport for London, 2014: 23). This ULEZ will come into force from 2020.

## 5.5 Chapter Summary

In Chapter Four, the rationale for this chapter providing contextual information was established. Methodologically, Chapter Four demonstrated that it is important to have an appreciation of context in order to be able to situate the case studies against their backdrop. Yin (2009) recognised this within the 'Case Study' method. Furthermore, as the literature review in Chapter Two explored, with the multi-level perspective of transitions theory, there was also a recognition that 'niches' and 'regimes' are set against a backdrop of the 'landscape'. The landscape provides the slow changing context that provides a setting for actors at the regime and niche levels. This chapter provided a description of some of those 'landscape' factors with a focus on the UK context.

In this chapter, it was demonstrated that private mobility is an important and durable part of the UK transport mix. Some of the reasons for UK consumers' reluctance to switch to ULEVs was explored. Through exploring statistics, it could be seen that whilst the environmental performance of the UK industry is improving, uptake of ULEVs is still low.

This chapter set out to expand upon the UK context in which all of the case studies are based through a 'STEP' analysis of the factors affecting automobility in the UK Market for ULEVs. Through an examination of Socio-cultural, Technological, Economic and Political factors, the chapter set out generic information about a range of factors that have the potential to impact upon the strategy and operating environment of firms in the UK car industry. This information was set out separately in this chapter as it is common to all of the cases; so providing a separate chapter of context avoided duplication and repetition in the cases themselves.

This chapter provided the context for both case studies – Chapter 6, 'Case Study I – TNC / MNC Vehicle Manufacturers' and 'Case Study II – SME Vehicle Manufacturers'. Whilst the UK context is very significant to firms manufacturing electric vehicles in the UK, it is important to consider that many of the larger vehicle firms operate within an international context which extends beyond the UK.

## Chapter 6:

### Case Study I- TNC/MNC Vehicle Manufacturers

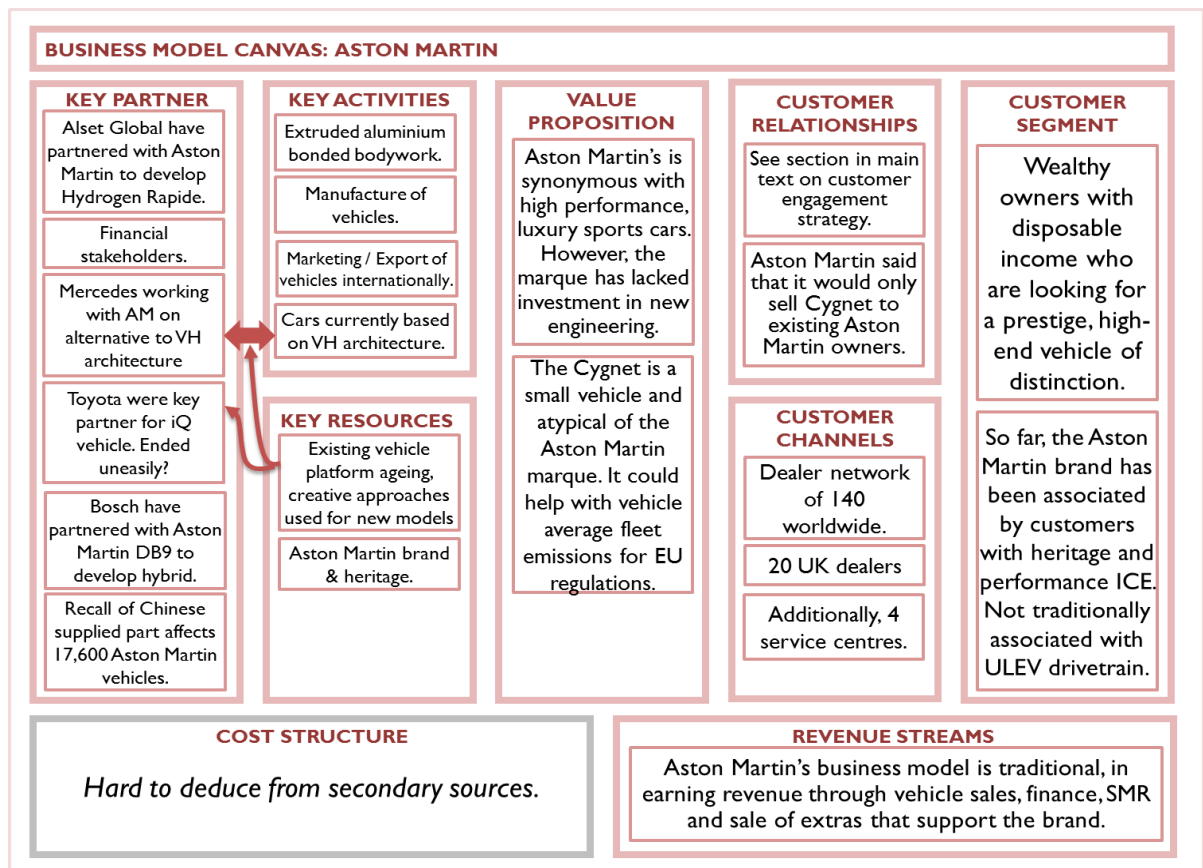
In this case study, the business models of the large incumbent auto manufacturing interests in the respect of introducing zero emission vehicles to market are critically examined. Within this case study, the scale of production varies dramatically. As has previously been discussed, in drawing a line between the two cases, there is a challenge in knowing where to delineate between them; smaller marques like Aston Martin and Rolls Royce producing vehicles in much smaller numbers than concerns such as Vauxhall, Toyota, Nissan and Honda.

Within this case study, there are a group of producers that cater for the 'mass market'; these include BMW's MINI marque, Honda, Nissan, Toyota & Vauxhall. The defining features of these embedded cases are that their vehicles are produced in pressed steel bodywork. As has previously been argued in Chapter 3, from this key decision, many other decisions about the nature of the automotive business model are defined.

However, one of the distinct features about the phoenix-like UK motor industry is the revival and turn-around of many of the UK's premium brands under new ownership: Aston Martin, BMW owned Rolls Royce and Tata owned Jaguar Land-Rover. These are vehicles produced in lower volumes than the 'mass market' TNC/MNC VMs. Almost universally, these vehicles are geared towards high-performance and ultra-luxury at the premium end of the market; perhaps in sustainability terms, these vehicles all encourage inherently unsustainable consumption behaviours.

That said, consumers at this end of the market expect sometimes demand world-leading technology and here alternative drivetrains are seen as improving the refinement and perhaps performance of vehicles as well as any environmental improvement.

## 6.1 Embedded Case Study: Aston Martin



**Business Model Canvas 7 - Aston Martin Business Model**

Date	Event
1913	Aston Martin founded by Lionel Martin and Robert Bamford.
1947	Aston Martin acquired by tractor manufacturer "David Brown". The Aston Martin "DB" line of cars is launched, which grows to be renowned.
1975	Sold to American owners.
1987	Ford buys 75% stake in Aston Martin
1994-2007	Aston Martin is a wholly owned subsidiary of Ford Motor Company
1999-2007	Aston Martin is brought within Ford's "Premier Automotive Group", created to manage
2005	Aston Martin 'record sales' of 4500 vehicles.
June 2007	A consortium led by Prodrive CEO David Richards acquires 90% stake in Aston Martin, Ford retain a 10% stake.
May 2013	Italian financiers Invest Industrial acquire 37.5% stake in Aston Martin, investing
May 2013	Bosch develops DB9 Hybrid, based on Aston Martin DB9 platform.
2013	With Alset Global, Aston Martin develops Hybrid Hydrogen Rapide S vehicle.
2013	Aston Martin Announces deal with Mercedes AMG in exchange for 5% non voting shares. Aston will access engine technology.
2014	Recall of 17,600 vehicles made since 2007; 75% of vehicles made in that time due to fault with Chinese produced plastic part.

Timeline constructed from: (Aston Martin, 2010) (Bailey, 2014) (BBC, 2007) (Lane R. , 2013) (Kew, 2013)

**Table 20 - Key Events in the Aston Martin Timeline**

Aston Martin emerged from its period of ownership by Ford, where it was latterly a constituent part of the Ford's high end marque collection - the Premier Automotive Group. Brooker, Thonton & Rugh (2010) suggested that Aston Martin faced "*challenges to its existing business model due to ever-tightening fuel economy and emissions regulations*". This has led the firm to look at alternatives and lower emission vehicles to complement Aston Martin's high performance offerings.

Alongside this narrative of searching for complementary low emissions products, there is another narrative of seeking economies of scale within the company and technical solutions to help the company move beyond some of the engineering that has underpinned its vehicles and is fast becoming dated. Bailey (2013b) notes the need for Aston Martin to tie up with a big partner, given the high costs of new model development. Looking at ULEVs within the wider portfolio of Aston Martin's products, it has faced challenges to development of new models, as its "VH, Vertical-Horizontal" vehicle platform is ageing and its product offering is narrow. Given financial constraints, the way that the marque has developed new product offering is through trying to build relationships with **KEY PARTNERS** in order to source technologies and ultimately a platform to underpin the development of new vehicles going forward. The most interesting thing about the Aston Martin embedded case is the interaction between **KEY PARTNERS** and Aston Martin's **VALUE PROPOSITION**. The timely lesson from this case is that, whilst partnerships are particularly helpful in sharing knowledge and reducing costs, careful selection is essential for premium marques to ensure that they don't damage the brand's **VALUE PROPOSITION**.

There is an interesting challenge in terms of Aston Martin's brand management. The DB9 Hybrid and Rapide S, discussed in more detail later are prototype vehicles that, whilst moving towards ULEV technologies, are clearly in-keeping with Aston Martin's brand image of cool, debonair motoring. However, the Aston Martin Cygnet, based on a Toyota iQ, somehow doesn't fit with the image of the marque.

So here is a case of a **KEY PARTNERSHIP** failing because the product developed did not have a **VALUE PROPOSITION** that would satisfy Aston Martin's **CUSTOMER SEGMENTS**.

There is another example of how Key Partnerships need to be managed carefully from the perspective of both the brand's **VALUE PROPOSITION** and the **CUSTOMER RELATIONSHIP**.

Bailey (2014) has discussed how Aston Martin has had to issue a product recall for a total of 17,600 vehicles. These are all found to have used a defective component made by a Chinese manufacturer from counterfeit plastic. This raises several points. Whilst a recall of this nature is challenging for any manufacturer, the situation is particularly acute for Aston Martin; as a percentage of the vehicles they have produced over the past few years, this is a particularly high number. Also with components being shared through platforms across vehicles, a failure of a component has the potential to affect many vehicles used across a whole range of products. Finally, is using key partners in a low-cost country congruent with the brand's **VALUE PROPOSITION** of being a high-end marque? Given the talent for automotive manufacturing in the West Midlands, Bailey (2014) notes how sourcing parts closer to home under the banner of "Made in Britain" may be compelling to Aston's **CUSTOMER SEGMENTS**.

For the time being, the major new development in the Aston Martin story is the announcement of a tie-up with Mercedes AMG. Tying in to the earlier conversation of making sure that **KEY PARTNERS** are congruous with the **VALUE PROPOSITION** of the brand; it has been said explicitly that Aston Martin will not be "co-branding vehicles" with the "Powered By AMG" branding; it would seem poor show for James Bond's quintessentially English brand of choice to suddenly be annexed by Germanic branding. Mercedes also seem keen to share knowledge but keep their respective brand distant.

At the moment, these alliances are based around sharing engine technology, and using Mercedes advanced knowledge in vehicle electronics.

Although recent articles seem to suggest that negotiations had come to an end, it has also been reported (Kable, 2011) that, in return, Aston Martin may act as a contract manufacturer (see page 148) for Mercedes, leveraging its specialist knowledge of low-volume vehicle production in order to produce Mercedes' next generation of Maybach vehicle. As Aston Martin is geared to smaller production runs, it is believed that this approach may be more efficient for Mercedes, than for them

to manufacture these specialist vehicles themselves. There is speculation that future Maybach models may also have mild hybrid technology (Lavrinc, 2010)

How do these discussions fit within the overall framework of this thesis discussion about the transition to ULEV's? As a company that is struggling for investment in new product development, Aston will need to work with **KEY PARTNERS** to develop any new vehicle offering, even to continue with their traditional ICE vehicles, not just ULEVs. Aston Martin have worked in partnership with a number of other **KEY PARTNERS** to deliver a range of ULEV prototype vehicles (see page 269), which could give clues as to the future development trajectory of the company. It remains to be seen whether these new technologies will fit within the direction of future model developments with Mercedes-AMG. With the new partnership based on Mercedes technology platforms, it may be the case that these one-off initiatives fall by the wayside, in favour of shared ULEV technology development on the Mercedes platform. Indeed, it has already been expressed that many of these projects are not slated for production; however, they start to build a narrative of how the Aston Martin brand might align with greener technologies, whilst not compromising on the performance that is key to the **VALUE PROPOSITION**.

Mercedes AMG have shown interest in ULEV powertrains; the SMS AMG Coupe electric drive (Mercedes AMG, 2014) is one such offering. An electric drivetrain producing 552 kW (751 hp) provides 0-100kph performance of 3.9 seconds. Were Aston Martin to adopt this technology, in the same way that they have adopted AMG's V8 petrol engines, the solution produced would clearly fit with Aston Martin's performance image.

### **6.1.1 Cygnet**

The Aston Martin Cygnet is also included in this case study. It is not a ULEV by conventional standards, however, it is a low emissions vehicle compared to others in the Aston Martin marque and represents an attempt by Aston Martin to reduce the average fuel emissions of the vehicles they produce. Ritson (2011) posits that the motivation for the Cygnet's launch was to ensure that Aston-Martin did not exceed the EU's new emission standards which were introduced in 2012, allowing fines to be levied

against firms whose average car emissions exceed 130g CO<sub>2</sub>/km/. This situation is particularly acute because, unlike other luxury marques which sit as part of bigger automotive conglomerates (Selling frugal Fiat 500's offsets the emissions from a Ferrari), Aston sits as a single branded house.

The Cygnet was the result of an alliance with **KEY PARTNER** Toyota to launch a small Aston Martin vehicle. The CEO of Aston Martin, Ulrich Bez noted that the Cygnet demonstrated Aston Martin's "commitment to innovation and integrity", whilst respecting the need to "satisfy demands of emissions and space" (Aston Martin, 2010). ", which at the time, it was proposed "that the Cygnet proposes a partial solution". Aston Martin have taken the Toyota iQ as the base platform and reworked the vehicle with a luxury interior and modified body styling which shares visual cues with the rest of the Aston Martin range. Aston-Martin launched the Cygnet in 2010 in Harrods' Christmas Window display. It planned to manufacture 3000 a year from 2011 (Ritson, 2011). Despite these lofty goals, eventually sales of only 150 per annum materialised (BBC, 2013a). The price of £32,000 - three times more than the Toyota iQ on which the Cygnet was based - was seen as one of the major reasons for the failure of the model (BBC, 2013a). The value that Aston Martin added through Key Activities was obviously insufficient to improve the vehicle's value proposition to warrant a price that much greater than the base iQ.

It could at first be thought that, considering it in terms of Ansoff's matrix, the Cygnet represented a 'diversification' strategy by selling a new type of product to reach a new market. However, Aston Martin's stated intention of only selling the Cygnet to existing customers grounds the Cygnet as a 'product development' as, whilst being a new product, it can only be sold to a present market. This is a curious choice of strategy, perhaps the intention was to make the vehicle appear "exclusive", yet it only served to limit the market for the vehicle.

There are some indications that the relationship between Aston Martin and Toyota did not end amicably. Ross (2013) quotes Aston's CEO as saying that the reason the project was stopped was, as Toyota was dropping the iQ in 2014, the lack of support from Toyota prevented the development of either a supercharged model or model for the US market. Tisshaw (2013) expands upon the



frustrations by noting that, whilst he felt like the firm had a good relationship with Akio Toyoda, Toyota CEO, he felt that Toyota had not “*followed up support like it does with Tesla and its marketing of other products*”. Toyota did not comment on the story. (Tisshaw, 2013).

### 6.1.2 DB9 Hybrid

Bosch has worked with Aston Martin (Phillips, 2013) to develop a Hybrid Aston Martin DB9. The technology boosts the performance of the 6 litre V12 from 510bhp to ‘over 740 bhp’ (Phillips, 2013). The technology boosts the 0-62mph speed from 4.2 seconds by over 20%. The drivetrain has an all-electric range of ‘close to 20 miles’ (Lane R., 2013). Given this relatively modest range, it can be seen that the main **VALUE PROPOSITION** of this approach is increased performance; environmental gains being a secondary benefit.

What is particularly unusual about the approach to hybridisation is the unusual technology configuration chosen. Bosch describe the technology as “modular”, adding that it is designed to be easily retrofitted with some work onto existing sports car configurations (Phillips, 2013). However, from a sustainability point of view, this adds 300kg to a vehicle that already weighs 1785kg.

The vehicle on which the hybrid is based is a rear-wheel drive vehicle. Onto this, has been retrofitted, two electric motors to drive the front wheels of the vehicle. Additionally, a third motor is fitted onto the engine belt from which power is taken up (Lane R., 2013). This hybridisation significantly improves the sports car **VALUE PROPOSITION** of the DB9. It transforms the vehicle into a four wheel drive and, by balancing the power sent to each of the wheels, the dynamics and performance of the vehicle can be tuned to suit the driving conditions. This is done through torque vectoring, supplemented by Bosch’s ESP system. Phillips (2013) notes how Bosch ‘pitched’ the idea to Aston and took one of their vehicles for modification, as the companies already have a strong pre-existing relationship. Bosch had seventy-four engineers working on the vehicle (Phillips, 2013). Lane (2013) has noted that Aston Martin’s role was confined to the supply of the vehicle.

Aston Martin have been clear that the vehicle isn't destined for production, however, as Phillips notes (2013) *"Instead, it shows one direction for hybrids to take in the future, and one that fits in with Aston's brand values."*

### **6.1.3 Hybrid Hydrogen Rapide S**

Aston Martin (2013) working with the **KEY PARTNER** Alset Global have developed a *"prototype twin turbo charged 6.0 litre V12 engine"*. This follows the 'hydrogen internal combustion engine' route that has been championed, notably by BMW in their Hydrogen7 vehicle. The H2ICE can run from hydrogen, petrol or a combination of both (Aston Martin, 2013). The vehicle contains four hydrogen tanks that hold 7.7lb of hydrogen at 350bar pressure (King, 2013).

Alset Global, an Austrian firm, have said that, by making internal combustion engines "dual fuel" and giving them the option to run on both hydrogen or petrol, gets around the challenges with infrastructure faced by pure hydrogen vehicles (Kew, 2013).

Whilst running hydrogen in an ICE engine allows for dual-fuel, surpassing infrastructure hurdles, it is much less efficient than converting the hydrogen into electricity, with a fuel cell, and then powering an electrical motor (Kew, 2013).

## **6.2 Embedded Case Study: BMW (MINI, Rolls Royce)**

In the UK context, this thesis looks at two iconic British brands that are now owned by BMW: MINI and Rolls Royce. Whilst one of these is renowned for its compactness and the other for its size, both brands are associated with the higher ends of their respective segments. Rolls Royce has throughout its lifetime been a premium high end brand associated with ultimate luxury. The original Mini was created in 1959 as a car for all people and achieved iconic status over its 41 years of production. BMW, having acquired Mini as one of the vehicles in the Rover group, took the model and turned it into a distinct marque of its own.

### **6.2.1 MINI**

The original Mini, launched in 1959, was originally designed as a utilitarian vehicle designed to transport four adults economically; however, very quickly, the Mini achieved iconic status and was beloved by celebrities, the aristocracy and the British public alike. After 41 years of production in the same body-shape (albeit with variants), the MINI under BMW's stewardship has capitalised on the cult nature of the brand and repositioned the vehicle, not as a utility car for the masses, but as a luxuriously appointed compact vehicle for the better off. Retaining much of the quirkiness and style for which the original MINI was associated but underpinned with a more modern approach to vehicle engineering, BMW revamped MINI has gone on to achieve much of its forbears success, both in the UK and export markets.

What is particularly interesting is how the MINI has been used as a platform on which BMW could experiment to gain knowledge about electric vehicles. The MINI E is an interesting embedded case, as it shows how TNC/MNC car manufacturers can deploy electric vehicles under the umbrella of one of its subsidiary brands as a 'test bed' for 'business modelling'. The MINI brand must also be seen in the context of the greater BMW group's business strategy. Since early developments with electric MINIs, BMW then went on to launch the subsidiary brand "BMW<sub>i</sub>" for plug-in electric vehicles. This uses knowledge gained from trialling electric drivetrains but with carbon fibre bodywork (BMW, 2014).



**Figure 87 - MINI E - A Business Modelling Tool?**

The vehicle above was exhibited at the LCV 2013 show for low carbon vehicles. It features in its window a notice that the Mini E is being deployed as a tool for business modelling, a point that will be returned to in the analysis (on page 406).

It was announced (Pollard, 2008) that just 500 MINI E cars would be built for corporate and private customers in the US market, although a handful might make it to London. Initially, the Mini E would only be available for a year, with cars being returned to BMW at the end of the trial (Pollard, 2008). This was to test the viability of an 'all electric MINI. In initial development versions of the MINI E, the rear seats were lost as the electric drivetrain was located above the rear axle.

Through offering a high degree of customisation and a range of different product offerings [MINI Hatchback, MINI Convertible, MINI Clubman, MINI Countryman, John Cooper Works] within the "MINI" brand, the current MINI **VALUE PROPOSITION** targets affluent people seeking a premium product. It is interesting to make more retrospective comparisons between the original BMC/BL/Rover business model for the original Mini and BMW's current offering.

*"MINI's business model hinges on buyers being lured into the showrooms [and paying for the] vast array of optional extras and desirable upgrades" (Walker, 2009)*

In writing about the MINI Countryman, Maltzan said (2010) “BMW’s business model is impeccable. Expanding the range not only attracts new customers but lowers production costs at the same time”. Indeed, this was a model used by numerous previous owners of the Mini brand, (Laban, 2005, p. 79) where shared components and variations of the same vehicle increased the numbers of market segments the vehicle could appeal to, whilst gaining economies of scale from using identical components across the range. Perhaps the MINI E, if released by BMW as a product for purchase, could be seen as an extension of this strategy, adding another variation to the MINI marque that appeals to a different **CUSTOMER SEGMENT**.

MINI have sub-contracted production of variant MINI vehicles to contract manufacturer Magna Steyr (See p.148 for further information on the contract assembly BM). The MINI Countryman is produced in Austria (Auto Express, 2010) as is the MINI Paceman ‘Sports Activity Coupe’ (Goldthorp, 2011) which is based on the Countryman underpinnings.

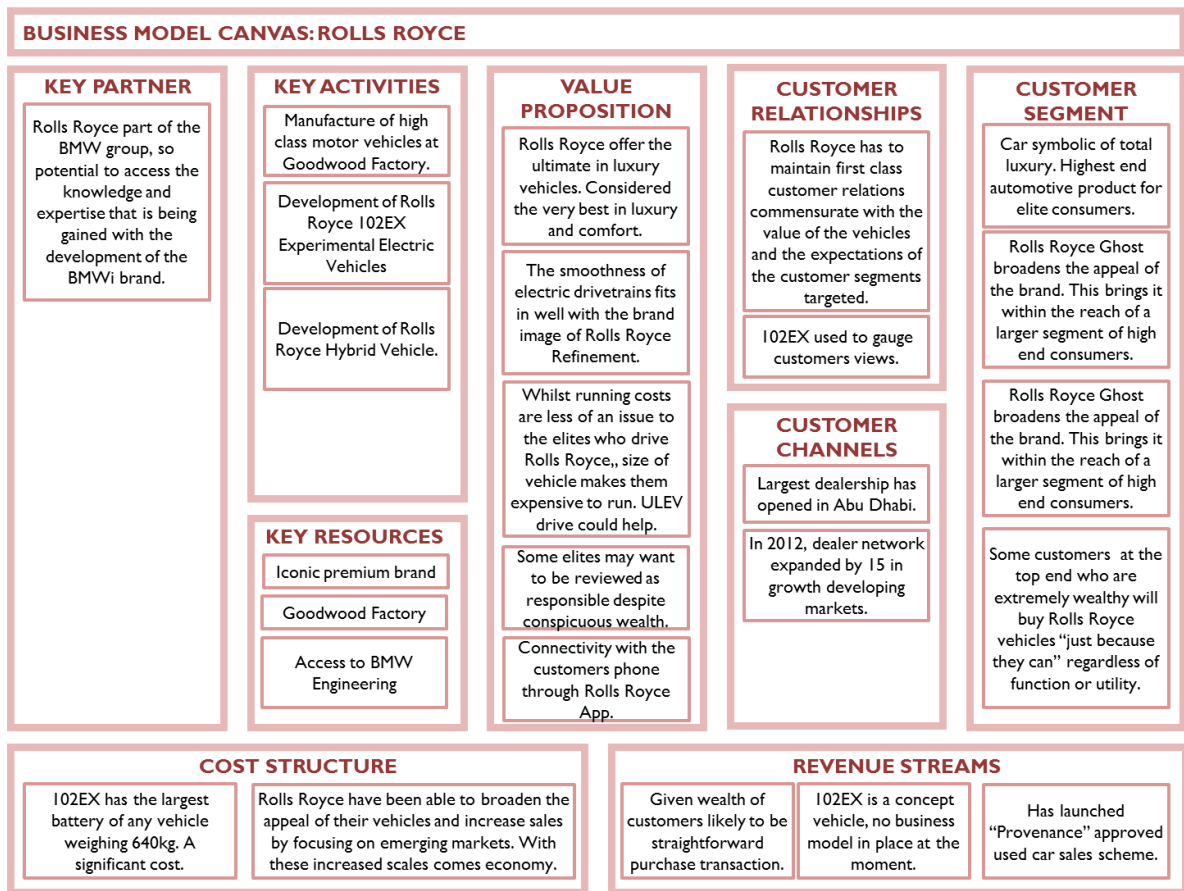
As (Winton, 2009) has observed, unlike premium brands Audi, Lexus, Acura and Infiniti which share components and platforms with volume brands VW, Toyota, Honda and Nissan, BMW does not have the scale

Two contrasting views on BMW’s business model are presented by Winton (2009) of BMW’s business model. Max Warburton of Bernstein Research sees fundamental challenges to BMW’s business model – profit margins have been affected by poor foreign exchange on exported vehicles,

Prof. David Bailey, of Coventry University, believes the future may be more positive for BMW. Whilst conspicuous consumption is less popular in those countries hit hard by recession, the same attitude does not prevail in the rapidly developing BRIC countries.

He believes by forging **KEY PARTNERSHIPS** with other companies (as it has done with Peugeot for engines for both the Mini and BMW 1 series) may help reduce development costs in the face of challenging CO<sub>2</sub> targets for a premium focused brand.

## 6.2.2 Rolls Royce



Rolls-Royce the luxury car maker needs very little introduction, it's ultra-luxury brand being synonymous with quality, grace and style. The Rolls-Royce Ghost has allowed the brand to reach new customers, with 80% of its buyers having never owned a Rolls Royce.

In 2008 Rolls Royce sold a record number of cars, 1,212 – in 2009 this dropped – in common with all automakers – to 1,002 however, in 2010, sales were up 171% on 2009 (which is assumed to mean sales of 2716). The USA is the largest market for Rolls Royce followed by China and the United Kingdom with 'significant growth' in Asia Pacific, the USA and the Middle East.

With the current Rolls Royce Phantom returning a fuel economy of 15 miles to the gallon, with careful driving a Rolls-Royce is not a choice for the eco-conscious. Such considerations are unlikely to factor into the decisions of consumers in this segment. However, there may be other imperatives driving Rolls-Royce's investigation of electric drive trains. Speaking in 2008, former CEO Purves said 'I can

*imagine a time when city or state authorities may ban cars from towns that exceed a certain level of CO2 [...]‘We may need an electric car merely to sell in certain parts of the world.’*

Rolls-Royce has not had to introduce smaller models to avoid fines under forthcoming EU regulation—where Rolls Royce sits as a BMW brand, emissions of sales of its vehicles are offset by smaller vehicles (1-series, MINI) under the BMW umbrella.

The firm has very long distribution channels globally, it has recently opened a dealership in Abu Dhabi said to be the largest Rolls Royce dealer in the world (Phillips , 2011) furthermore, whilst European markets are struggling, there is growth in Asia-Pacific and the Middle East, prompting Rolls Royce to up their dealer networks from 105 to 120 (Ernst, 2012).

Rolls Royce customer relationships need to be very well managed in order to be commensurate with the value of the vehicles and the expectations of the customer segments targeted. Rolls Royce Motor Cars (2014) Rolls-Royce has extended its flexible manufacturing capability to allow customers an ever increasing range of bespoke customisation options.

It was announced in 2008 .that then Rolls-Royce CEO Tom Purves had the intention of developing an electric variant of the Rolls-Royce Phantom. Relating the technical potential to the value proposition, he said in *‘Many of our customers do small mileages exclusively in the city [...]‘For these customers, an electric Rolls-Royce would be ideal.’*”*“We stand for unmatched refinement and you can’t get a quieter and less intrusive engine than a well engineered electric [motor](#). Truly, the loudest noise you would hear would be the tick of the clock [...] also stand for strong and instant torque – and an electric motor delivers maximum torque instantly. The “waftability” would be fantastic.”*

In 2010, current Rolls-Royce CEO Torsten Mueller-Oetvoes heightened speculation about the possibility of introducing an electric Rolls-Royce vehicle by saying that an alternatively fuelled vehicle would be a ‘good idea’. but added the caveat *‘We are not going to make any rash decisions. It would be wrong for the brand and wrong for our customers if we were to take a decision without fully exploring all*

options. The culmination of speculation about the potential for an electric Rolls Royce is the I02EX, Phantom Experimental Electric Project.

Launched at the 2011 Geneva Motor Show (Williams, 2011) the Rolls Royce requires over half a tonne of batteries (640kg) more than any other electric vehicle to date, in order to give the heavy vehicle a range of 125 miles. The batteries are configured to occupy the space previously taken up by the cars engine and gearbox. However, the quantity of batteries presents significant challenges from a charging perspective, a “slow charge” can take up to twenty hours, whilst a “fast charge” could take up to eight (Williams, 2011). Poor from the perspective of usability, but then perhaps those who might comprise the target market would find it small financial inconvenience to buy a second vehicle. Madslein (2011) notes, that “there are some customers who buy cars just because they can”, noting the diversity of Rolls Royce’ wealthy customers.

The electric variant is marginally slower than the V12 petrol equivalent, taking 8 seconds to go from 0-60 over the V12’s 5.7 seconds (Williams, 2011). However, the drive train is smooth and silent, with the only noise coming from the tyres (Madslein, 2011)

***“The alternative drive-train we choose must deliver an authentic Rolls-Royce experience. It must be a technology that is right for our customers, our brand and which sets us on a sound footing for a sustainable future. That is why this project is so important.”***

---

**Rolls-Royce CEO Torsten Müller-Ötvös quoted in Williams (2011)**

In terms of the cost structure of the I02EX, as it is not in production it is hard to know exactly what price the vehicle would be if it hit the marketplace, however, Madslein (2011) had spoken with Müller-Ötvös who noted that electric vehicles often attract a 50-100% price mark up when compared with conventional vehicles. This could mean that in production, the vehicle would cost anywhere up to £600,000 – not a problem for some of Rolls Royce incredibly rich customers. Madslein (2011) notes that when it comes to the Rolls Royce brand, the logic of their customer segments differs completely from the mainstream market; here the ultra-high price tag is likely to be more of an attraction to its customers, making the vehicle even more exclusive and unattainable – and therefore more desirable.



Following these development and an enthusiastic release, Bowman (2012) noted that plans to develop the vehicle were on hold. Initial customer feedback was unenthusiastic about the range of the vehicle. Müller-Ötvös (quoted in Davies, 2013) felt that customer feedback was “ambivalent” about a purely electric Rolls Royce, noting that “heavy cars” were an integral part of the Rolls Royce “feel”, and this was a poor fit with pure EV technology. Furthermore, it was noted that many Rolls Royce customers lived outside of city centres, where the EV value proposition was most useful.

By early 2014, the position on ULEVs have softened slightly, (Davies, 2014) noted that Rolls Royce was considering developing a plug-in hybrid vehicle. In an interview with George (2014), Müller-Ötvös noted that developing a hybrid Rolls Royce would be imperative within the next two years.

Whilst there is a lack of specific details, George (2014) notes comments by Müller-Ötvös:

***"A Rolls-Royce cannot come with any kind of compromise, and both the recharging times and the range were not acceptable for our buyers [...] But with hybrid technology that is no longer a problem."***

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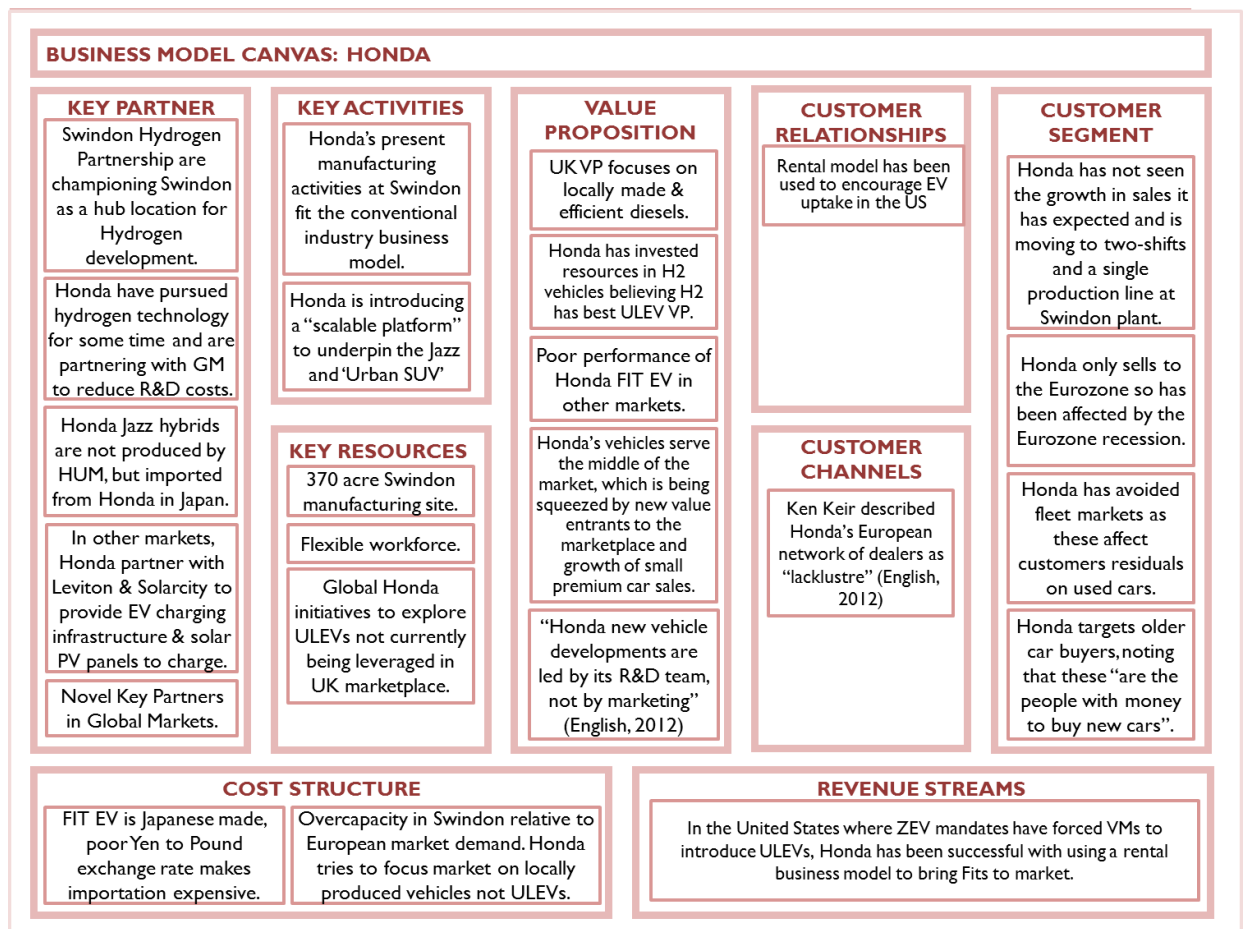
Rolls-Royce does not show any signs of radical business model innovation – but then perhaps it doesn't need to. Williams (2014) reported Muller-Otvos making specific reference to this - “We begin 2011 with a sustainable business model, a flexible workforce and great confidence in the future success of our company.” Bailey (2009) noted that despite the economic downturn, Rolls Royce was continuing to deliver a profit to its parent BMW at a time when it itself was loss-making, noting it's resilience in the economic downturn.

Whilst it would be easy to pick holes in the environmental sustainability of Rolls Royce operations, it is harder to question the economic sustainability of the business model in an economic environment where luxury marques prosper.

### 6.2.3 Other BMW owned brands

When acquiring Rover, BMW also gained the rights to a range of iconic British car brands. In an article by Autocar, a spokesperson for MINI revealed that an all-electric MINI coming to the market, may not debut under the MINI brand at all *“It is going to be a competitor to the G-Wiz; it will be a premium model. It won’t necessarily be a BMW or a Mini, it could be another brand like Isetta or Triumph,”* (Autocar, n.d.). BMW have registered trademarks relating to Triumph, which have caused speculation in the motoring press (Holloway, 2012). Were this initiative to come to pass, it would confirm an already interesting strategy by BMW, to differentiate brands based on novel ULEV technologies, from its traditional product offerings. This in turn helps manage consumer expectations about the **VALUE PROPOSITIONS** of its respective marques, and may help to more clearly define **CUSTOMER SEGMENTS** for green, and conventional brands.

## 6.3 Embedded Case Study: Honda



Business Model Canvas 8 - Honda Business Model

Presently, the Civic, Jazz and CR-V are made at the Honda plant in Swindon. Whilst most of the Honda Jazz models for the UK marketplace are produced at the Swindon plant, the Jazz Hybrid variant is still imported from Japan (Simister, 2011), with no ULEVs being manufactured at the Swindon plant at all. The Jazz hybrid is a mild hybrid, using a combined starter motor-generator.

Honda is introducing a new scalable platform to underpin their new vehicles (Velayudhan, 2014) which may include some hybrids. However, the engineering of this platform is conventional in many ways. The **KEY ACTIVITIES** that are taking place at the Swindon factory fit the conventional industry business model.

Within the UK, Honda's strategy for the introduction of Ultra Low Emission vehicles has been quite conservative. Their Fit (Jazz) EV model has not been introduced to the UK market. Holloway (2012) notes that, whereas vehicles like the Leaf are ULEVs designed from the ground up, the Fit EV "is -

drivetrain aside - almost identical to the combustion-engined version, save for a few styling tweaks and switchgear changes. Honda's model developments are led by the R&D team, not by marketing. English (2012) asserts, in discussions with Ken Keir, Executive VP of Honda, that this can lead to a "lack of continuity" and an "eclectic model range", but Keir "wouldn't have things any other way".

Perhaps one of the factors that has inhibited these more advanced models coming to the UK is the poor Yen to pound exchange rate (Holloway, 2012), which makes importation of the Japanese ULEVs expensive. (In contrast to for example Nissan, whose ULEVs are UK manufactured). That said, Honda have not witnessed the growth that they had been expected. In 2012, Honda were more buoyant about the prospects for the Swindon factory, moving to three shift working and recruiting an extra 500 staff (English, 2012). At the time, Ken Keir suggested that production of Honda Hybrid models might even move to the UK (English 2012) and, in February 2014, speculation was again raised that the production of the hybrid version may move to the UK (Velayudhan, 2014). However, this has not come to pass and Honda is withdrawing sales of its hybrid vehicles from the UK market. Grant (2014) notes that Honda have announced plans to drop the sale of Insight Hybrids and CR-Z hybrids in the UK marketplace with Honda "prioritising low-carbon diesels and locally made products". This focus on locally made products has perhaps been driven by overcapacity at the Swindon plant and the need to increase sales of the vehicles made there.

Considering **CUSTOMER SEGMENTS** Ken Keir notes that Honda targets older car buyers, (English, 2012). Looking at the innovation literature, age is often an indicator of willingness to innovate, with older buyers tending to be more conservative and fit in with the late market. Perhaps this explains some of Honda's conservatism with ULEV technologies, focusing on hydrogen as a longer-term ULEV solution. Furthermore, Keir notes that Honda has avoided the fleet market:

***"selling volume for volume's sake has never been in the Honda view. We have been inconsistent in corporate [fleet] markets at best, but we do protect our existing customers' residual values and for that I make no apologies."***

---

**Ken Keir, VP Executive, Honda UK in English (2012)**

The Honda plant in Swindon only manufactures for the European marketplace. As Harvey (2013) notes “a factory that only sells to Europe has to wait for a Eurozone revival before redundancy programmes like this can be consigned to history”. This is compounded by the fact that Honda is making a product for the middle of the market which, as has been noted in the global context, is being squeezed as customer segments in the middle of the market migrate either downmarket to the value segment or upmarket to the growing range of compact premium vehicles.

As a result of poor Eurozone sales over the past couple of years, their manufacturing operation has been scaled back significantly with resulting job losses. In January 2013, it was noted that production would be scaled back, with 800 job losses and 300 agency staff not having their contract reviewed (BBC, 2013b). In March 2014, it was announced that the Swindon plant would be moving to two shift working and a single production line (BBC, 2014).

In global markets, Honda has led technology by introducing the first hybrid vehicle, the Insight. It was Toyota however, who gained much more widespread recognition and commercial success with their Prius. In California, where there has been significant policy attention given to Hydrogen, Honda has been a key player with their CRX hydrogen sedan.

### **6.3.1 Honda Fit**

Honda have also explored electric vehicle technology. The Honda Fit is the current name for the vehicles formerly known as the Honda Jazz in the UK.

Greiling & Ohnsman (2013) have written about Honda’s FIT EV in other markets. With the goal of delivering 1100 vehicles, they had only managed to find customers for 176. Honda changed their US business model to offer the vehicles for rental and cut the prices they were being offered for dramatically to “fire sale prices” (Greiling & Ohnsman, 2013). This dramatically increased uptake of vehicles by customers and the company went from a position of carrying excess stock to having customer waiting lists and needing to apologise to customers that vehicles were not available. Clearly, there is a keen balance to find the price point EVs will retail at.

### 6.3.2 Honda FCX Clarity

In 2011, the UK's first 'open-access hydrogen filling station opened at Honda's plant in Swindon. (Automotive IT, 2011). This represents a significant investment in demonstrating the feasibility of Hydrogen Technology.

Whilst Honda's business model for ULEV's in the UK is not currently in the public domain, it is interesting to look at developments in Japan and the United States, particularly in the State of California, to learn something of their intentions. The Honda FCX Clarity is the world's first production Hydrogen vehicle (What Car, 2009).

***'It's our job to produce the vehicles to prove the business model and to encourage energy suppliers to put the infrastructure in place.'***

---

**Sachito Fujimoto quoted in (What Car, 2009)**

Establishing Swindon as a hub location for hydrogen vehicles has required the buy in of other local key partners, extending beyond the value chain into the public sector. A hydrogen roadmap has been produced for the Swindon area by the 'Swindon Hydrogen Group', Honda is one of the stakeholders alongside local universities, Swindon Council, the local LEP Swindon|Wiltshire, and other hydrogen and fuel cell companies. Furthermore, the policy narrative for alternative vehicles in Wales has differed from other part of the UK and strongly favoured hydrogen vehicles. Along with the position of Johnson Matthey along the M4, this has led to the M4 being considered a potential future "Hydrogen Highway".

Internationally, Honda have announced a partnership with General Motors to develop fuel cell technologies. (Casey, 2013). There may also be other stakeholders involved in this move, such as the US Army (Casey, 2013). Honda has invested heavily in fuel cell technology, believing it to be a long-term energy solution. Casey (2013) notes that General Motors in the years leading up to 2012 applied for the most patents on automotive fuel cell technology followed in second place by Honda. So this Key Partnership could make long term strategic sense for the Honda business model. Honda and GM have both gained extensive experience amongst VMs with Hydrogen, leasing their Fuel Cell clarity in both US and Japanese markets (Casey, 2013)

### **6.3.2 Innovative Key Partnerships**

There are other interesting Business Model innovations in the US marketplace. Honda have teamed up with Leviton (2014) to provide EV charging infrastructure, which is a more straightforward partnership. What perhaps is more intriguing is the partnership with “Solarcity”, which installs PV panels onto the roofs of both customers and also Honda dealerships, to produce Zero Carbon electricity with no up-front capital investment on the part of the customer. This is an innovative business model that packages technology with finance in order to deliver electricity at lower cost than customers’ utility providers. What is interesting is the engagement of a VM in this parallel transition, addressing some of the technical questions of where the electricity for Zero Carbon Vehicles will come from.

## 6.4 Embedded Case Study: Jaguar Land Rover

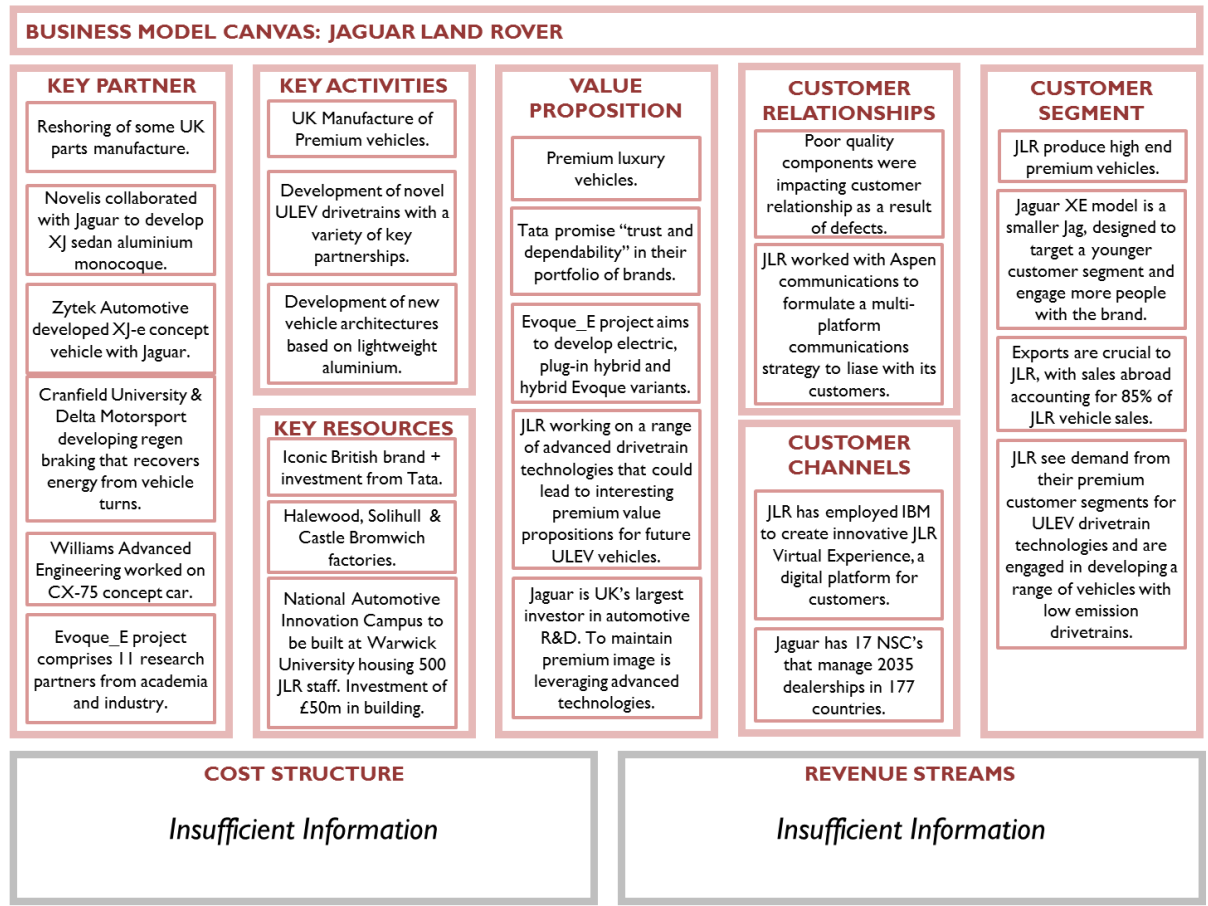


Figure 88 - Jaguar Land Rover Business Model

Nussbaum (2008) writing shortly after the acquisition of Jaguar Land Rover (JLR by Tata, draws attention to innovative aspects of Tata’s Nano business model and suggests “the same kind of game-changing, disruptive innovation is needed for Jaguar and Land Rover.” Suggesting the same kind of business logic that have been applied to small, low-cost cars can be applied to large, luxury cars.

When Tata took over the Jaguar brand, they promised “trust and dependability” (Economic Times, 2010)

*The value proposition of the other two brands — Jaguar and Land Rover — is very different, but the same basic principles hold true. Land Rover is a better understood, somewhat a stronger brand, delivering a unique set of values. It gives people the feeling that when you drive this car nothing can happen. Some refer to it as a fortress on wheels...a car that gives a feeling of safety and security. These brand values perfectly fit with the Tatas.*

Carl Peter-Forster Tata Motors CEO & MD quoted in Economic Times (2010)



Jaguar Land Rover (2013) invests the largest amount in Research & Development amongst UK based vehicle manufacturers. They have also championed the National Automotive Innovation Campus at Warwick University, a centre that will research advanced drivetrains and future technologies. It will see Jaguar Land Rover double the size of its research and development team. This is a significant £50million investment by the company, and the 30,000 m<sup>2</sup> campus will be a forum for industry to interact with academia (Harris, 2013).

Jaguar Land Rover's customer relationships had suffered as a result of quality issues emanating from suppliers. As a result, JLR have made significant moves to "reshore" (Pozzi, 2013; Bailey, 2013c) component manufacture to UK companies where quality can be managed more effectively.

Jaguar Land Rover have announced their intention to bring a pure Electric Vehicle to the marketplace in the next 10 years (Ebbs, 2014b). The driving force behind this, according to Dr, Wolfgang Epple, is to meet emissions regulations, believing that an EV will need to be in place by 2025, potentially sooner in some markets. Whilst JLR were reticent to reveal the full extent of their market analysis, they revealed

***“And I personally think that the hybrid drive will become the dominant drive train in the upper vehicle classes [...] I cannot say too much but we are observing the market (electric vehicles) carefully. There is a market that is much more relevant to us as the second or third vehicle in the family, and it makes sense to have an alternative drivetrain or electric car to compliment the first car in the family.”***

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**Dr Wolfgang Ziebart, Group Engineering Director, JLR**

In terms of customer segments, foreign sales are particularly important, Jaguar Land Rover (2014) is one of the UK's biggest exporters, with exports accounting for 85% of JLR sales. Tata has announced its intention to expand into the Chinese marketplace and intends to open a plant in China producing 40,000 vehicles a year with Land Rover being the first brand to make the transition (Bowman, 2010).

Jaguar are also targeting a younger demographic (Lienert, 2014). Their new Jaguar XE vehicle is a smaller vehicle that is designed to chase a key demographic that are buying vehicles such as the BMW

3 series and Audi A4. The vehicle is based around the Aluminium Architecture Jaguar designed for the CX-75 concept vehicle (Lienert, 2014).

In terms of the Key Processes, Jaguar Land Rover have a long experience of working with aluminium. After the Second World War, steel was in short supply so the first Land Rover Defender vehicle was built in 1948 from aluminium (Foy, 2013). Foy (2013) notes that Jaguar Land Rover's bodyshop at Solihull is the largest aluminium one in the world, and manufactures both the Range Rover and Range Rover Sport here. The weight savings through using aluminium amount to around 20% of the equivalent steel vehicle weight, or 500kg. This results in a 22% fuel saving compared to the Range Rover's steel predecessor (Foy, 2013). Jaguar worked with Novelis (Aluminum Association, 2011) to develop an aluminium monocoque for their XJ.

Jaguar Land Rover (2014) have invested £45m in a new stamping line at Halewood. Designed to work with both steel and aluminium, the press equipment itself is of a new 'servo' type of operation (Jaguar Land Rover, 2014) which uses less energy and can recover energy that would be otherwise wasted. Furthermore, there is a great increase in flexibility as dies can be changed in 5 minutes, compared to the existing 55 minutes on the mechanical press lines. (For an explanation of servo press technology see Heston, 2008 who provides an in depth analysis of the technology and its impact on stamping)

Furthermore, the increasing use of aluminium in manufacture results in further energy savings in manufacture. Rivets are used instead of welds, resulting in considerable energy savings in manufacture (Foy, 2013). Eliminating welding processes also reduces the demand for cooling in factories (Foy, 2013).

There is also interesting information in the Jaguar Land Rover (2014) press release, which gives clues as to the relative amounts of steel and aluminium currently used in vehicle manufacture, as it notes that at present, the lines make around 14 million hits\* a year into steel, and 1 million hits\* into aluminium.

\*A hit is a single impression in a metal stamping operation. Simple parts may require a single hit. More complex parts may require multiple hits to form them to shape. Multiple parts may be produced in a single hit, and the number of hits gives no indication of the size of quantity of parts being produced in each hit.

Jaguar has 17 National Sales Companies that manage 2305 dealerships in 177 different countries. This presents complex challenges in terms of managing customer relationships and customers' on-going

interactions with the brand. JLR engaged Key partner Aspen Marketing Services (Waxer, 2013) to develop novel customer relationship management systems.

***“Once a customer purchases a vehicle and becomes part of the family, we have to embrace their decisions; we have to validate their decisions and say they made a great choice throughout their ownership lifecycle [...] We have to keep them informed based on all their needs as a way to mitigate future defection. [...] For JLR specifically, we deploy a lot of really relevant content to customers [...] So when we send you an email that says you're due for service, there's the ability for you to engage a video library and a subject-matter expert to tell you exactly why your brakes are so important to maintain.”***

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**John Vierheller, Aspen Marketing Services' EVP of automotive quoted in Waxer (2013)**

Here it is apparent how important new digital content and new platforms are going to be in the future to managing the customer relationship. These new technologies also create opportunities for new customer channels. There is also evidence that JLR is engaging with innovative new approaches to customer channels and the customer relationship:

***Jaguar Land Rover worked with IBM Interactive Experience to develop the Jaguar Land Rover Virtual Experience, which is a digital application deployed on a PC-based system that allows customers to examine and change components of a virtual rendering of a car, using motion-detection technology. Customers are now able to engage and interact with almost life-size, high-resolution renderings of vehicles as well as take a 360 degree views of the exterior and interior, open doors, start the ignition and get detailed information on key features.***

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Core Jr (2014)

#### **6.4.1 Evoque\_E**

The JLR Evoque\_E project comprises a consortium of 11 different universities and industrial partners that have been funded by the TSB to develop three ULEV drivetrains for the Land Rover Evoque\_E. These will be hybrid, plug-in hybrid and fully electric variants (Harris, 2013). Here there are some interesting innovative technologies, in particular, Cranfield University and Deltamotorsport are working on a project to capture regenerative braking energy from differential wheel speeds on turning, whilst improving stability at the same time (Harris, 2013). What is particularly interesting, is that the

view JLR have taken is to develop the drivetrains within the constraints of the existing platform rather than a bespoke platform.

***“The aim of the project is to develop technology platforms which are configurable and compatible within the architecture of an existing production vehicle. The modular technologies include single and multi-speed axle drives; modular battery packs and integrated power electronics, multi-machine, advanced control development and torque vectoring.”***

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Peter Richings, Jaguar Land Rover Director Hybrids and Electrification quoted in Hayhurst (2013)

#### **6.4.2 Bladon Jets**



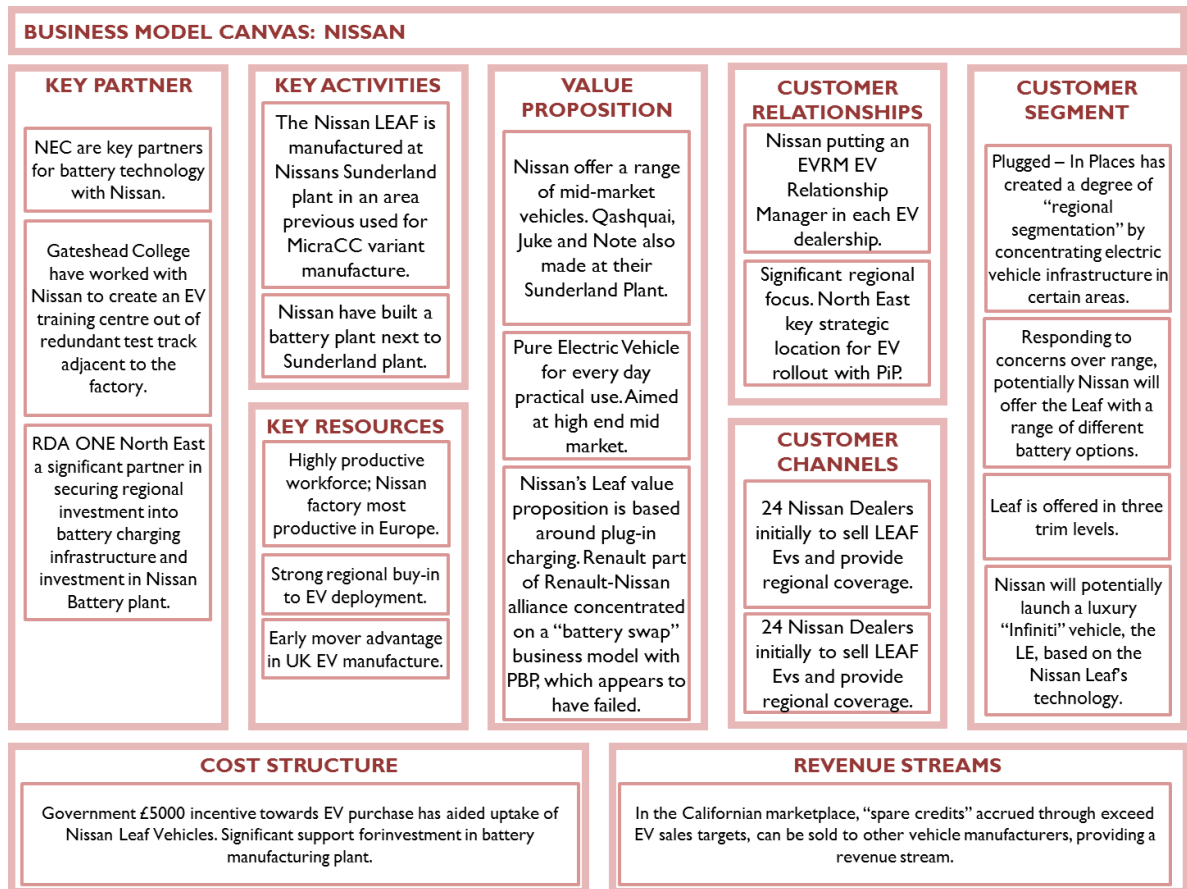
**Figure 89 – Jaguar CX-75 Concept Vehicle**



**Figure 90 - Bladon Jets Novel Gas Turbine Engine**

Another notable innovative drivetrain project was to “develop an ultra-lightweight, gas turbine powered, electric vehicle range extender that will enable vehicle weight savings of 100kg or more and a modest reduction in CO<sub>2</sub> emissions on the UNECE101 drive cycle” (Rideen, 2010) Jaguar partnered with Bladon Jets to showcase “the world’s first commercially viable - and environmentally friendly - gas turbine generator designed specifically for automotive applications.” (Rideen, 2010).

## 6.5 Embedded Case Study: Nissan



### Business Model Canvas 9 - Nissan (Leaf) Business Model

Amidst the global automotive crisis, Nissan decided to abandon mid-term goals that were set in its business plan for conventional vehicles, whilst maintaining the push into the electric vehicle market. This strategy appears to have worked well for Nissan, as Andy Palmer, Senior Vice President of Nissan, revealed in an interview (AWPresenter, 2010b). As governments around the world introduced stimulus to the automotive industry; Nissan were quick to respond with their "Leaf" electric vehicle.

#### 6.5.1 Renault-Nissan Alliance

It is interesting how Nissan and Renault have worked in partnership to develop their electric vehicle offering, yet the product offering both have arrived at is significantly different; Nissan choosing to champion a "plug in recharge" system, whilst Renault had planned to lead the way in 'quick drop battery exchange' for use with 'Project Better Place'. Whilst Project Better Place created a great deal of buzz, ultimately Renault's reliance on this Key Partner made their business model a hostage to fortune when PBP imploded. By contrast, Nissan's more conservative take appears to yield results.

An un-named Nissan Executive told Autocar (Saunders, 2009) *“We don’t think Quickdrop centres are the right business model for Europe,”*. In another interview (Chambers, 2009) Hideaki Watanabe, Nissan’s Division Manager of the Global Zero Emission Business Unit, expanded upon this point;

***“For the battery swapping, we don’t know what’s going to happen to EVs in the future,” he said. “We will not be able to control everything. But what we have to do is to be able to respond to various solutions that may come up. One option is the battery swap. Within the alliance it’s important to have someone working on that. But reversely, it doesn’t make sense for the two companies to do that. We’ve allocated that resource to the Renault side. If there’s a market or a business model which is favorable for the battery swap system, we can get the technology through our alliance.”***

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### **6.5.2 Nissan Leaf**

The development of the Leaf has marked a significant investment and risk for Nissan:

**Normal car development cost is about \$300 to \$500 million, and EVs are above the upper range of that... We’re looking at two stages: initially, at the 2010 launch - that’s when we’ll get all of the buzz and the aid and all the rest of it. That’s why we’re talking about mass-marketing in 2012, 2013. That’s when it becomes a viable, mass business in our business model.**

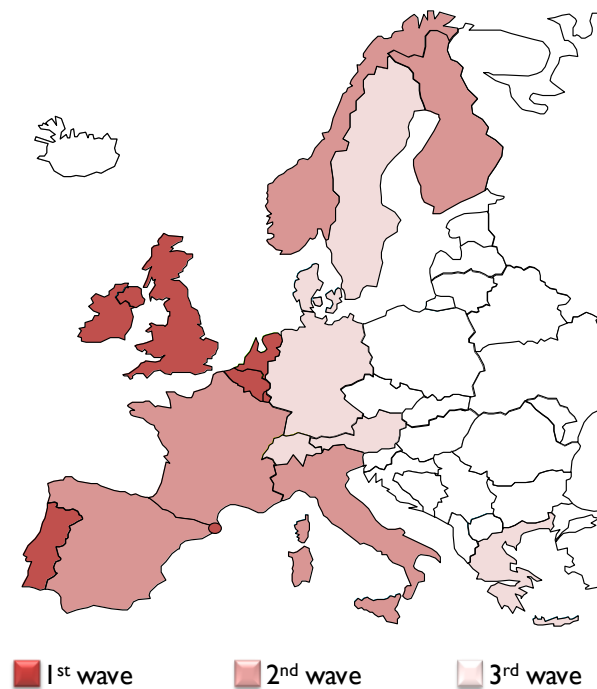
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**Andy Palmer, senior vice president and head of product planning, Nissan.**

The car’s styling is deliberately understated in order to position the car for mass-market appeal. Shiro Nakamura, Head of Design at Nissan is quoted as saying: *“We wanted this car to be distinctive and recognisable as a Nissan, but not too ‘out there’. It should look like a normal, familiar prospect, even if it won’t drive like one.”* (Saunders, 2009)

Nissan has established a Joint Venture with NEC to manufacture the batteries for its electric vehicle range. Nissan has also tried to address the problem of high battery costs through a collaboration with Sumitomo Corp. to give batteries a ‘2<sup>nd</sup> life’ after their initial use in vehicle applications. Called the 4R initiative (‘Reuse, Resell, Refabricate and Recycle’), Nissan (n.d.) will take back the batteries at the end of life and recycle them in applications such as load balancing for stationary power applications.

The UK is one of the early markets for Nissan's Leaf roll out, and there is a nation-by-nation EU plan as to how the Leaf will be deployed in various markets.



**Figure 91 - Nissan EU Market Introduction Strategy, Redrawn from (Hutt, 2010, p. 5)**

Careful consideration has been given to the customer channels that will be used to distribute Nissan Leafs (Green Car Guide, 2010). Initially, twenty-four dealers will specifically focus on selling Nissan Leaf EVs. They have all been supplied with EV Fast chargers, allowing Nissan Leaf's to be charged to 80% capacity in half an hour. Furthermore, the customer relationship with EV users is to be managed by a specially trained EVRM or EV Relationship Manager. This builds on experience Nissan gained with the GT-R supercar (Green Car Guide, 2010).

Nissan are also using some novel ways of creating new customer relationships. LeSage (2013) reports how Nissan are making "free EV charging available for six months". Not in the real world, of course, but in the computer game "SimCity", with electric charging being made available through a free downloadable add on, which improves the amenities available to the virtual denizens of your city whilst simultaneously advertising the Nissan Leaf to game players.

Nissan have announced plans to improve the value proposition of the Leaf, by improving its range with an upgraded battery pack (Wahlman, 2014). Nissan have also considered offering a range of batteries to their customers, finding market research into the sensitivity of different customers to the price they are willing to pay for range (DeMorro, 2014).

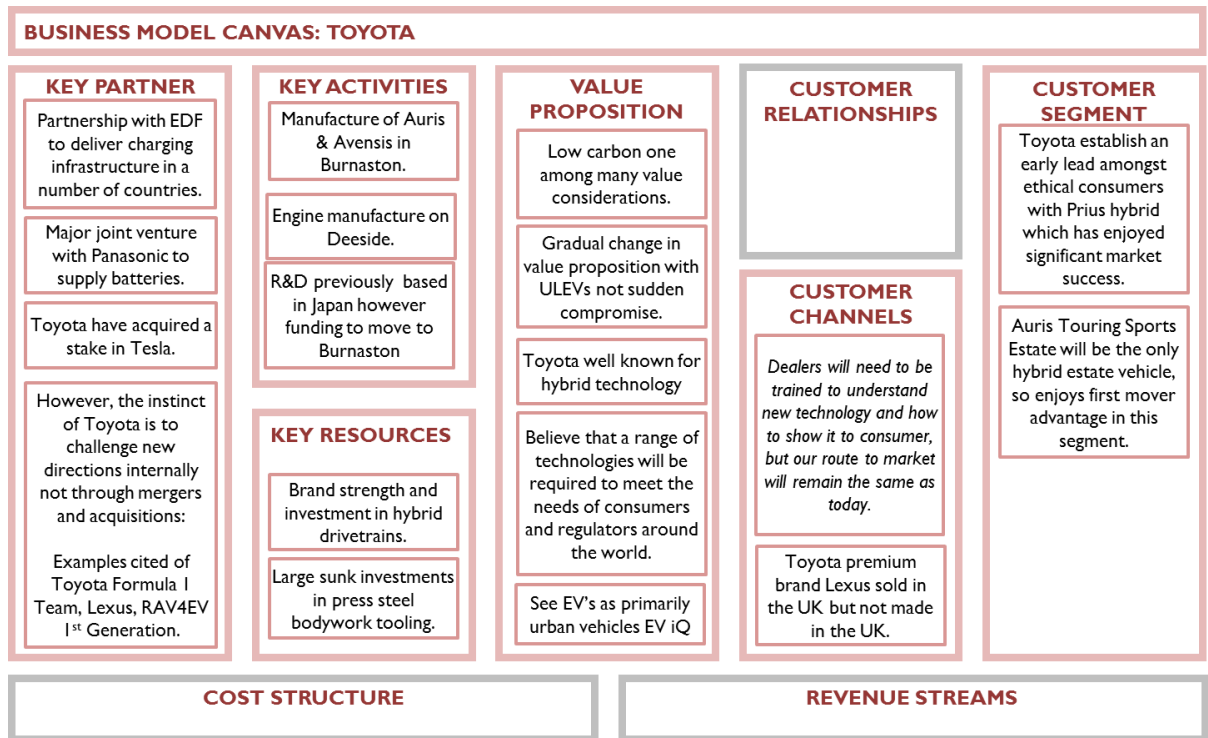
### **6.5.3 Nissan Leaf in Other Markets**

It is interesting also to examine Nissan's work in other markets, as this perhaps provides some glimpse of their future direction in the United Kingdom. In Japan, Nissan has partnered with NEC and Sumitomo to deliver electric vehicle recharging infrastructure.

In the Australian marketplace, Nissan is offering the Leaf as part of a leasing package, that should bring the cost of electric vehicle ownership down to the level of a conventional vehicle. According to Nissan Australia CEO, Dan Thompson (Mathioudakis & Pettendy, 2009), this will bring the vehicle into an ownership bracket which will undercut both the Chevrolet Volt PHEV and Mitsubishi's iMIEV.



## 6.6 Embedded Case Study: Toyota



Toyota is the world's largest passenger car producer. (Sunderland, An Interview with Toyota, 2009)

Graham Smith and Michael Valvo (Sunderland, An Interview with Toyota, 2009) both advanced Toyota's vision that there will be a range of technologies that serve future automobility needs and that, in the long run, different drivetrains will serve different customer demands. Toyota's policy has been to invest in research and development across a range of different areas;

The European context is also important for Toyota, with 85% of vehicles (Johnson, 2013) produced at its Burnaston plant exported to Europe. The Toyota plant has also benefited by moves from Japan to take monetary steps to weaken the Yen (DerbyTelegraph, 2013), which is of particular benefit to Japanese manufacturers abroad when repatriating profits.

There are also promising signs for the Burnaston Plant, with a total of £6.3 million of Regional Development investment being used to build research and development and design capabilities at the plant (Johnson, 2013b). At the moment, this work is conducted in Brussels but, with the new investment, some of the work will be moved to the UK. This is also seen as a positive development for Toyotas Deeside engine plant.

### 6.6.1 Toyota Hybrid Vehicles

In April 2013, Toyota announced promising signs in the number of hybrid vehicles exported to Europe, with sales of the Auris up 69.2% on the same period the previous year, and sales of all hybrid vehicles up 82.3% on the previous year.

Whilst Hybrid vehicles represent an intermediate solution, they are one that has proven popular with consumers as the adjustment from conventional vehicle to hybrid requires little adjustment. The environmental impact is significant too with Toyota announcing that the hybrid vehicle sales since 2000 of over half a million vehicles have collectively avoided 3.4 million tons of CO<sub>2</sub> (Johnson, 2013).



**Figure 92 - Toyota Prius Hybrid Vehicle**

Toyota established an early lead in ULEVs with their Toyota Prius Hybrid, an iconic vehicle that became a leader and flagbearer for hybrid drivetrains. In 2010, Toyota commenced production of its Auris Hybrid models at its Burnaston Plant in Derbyshire (BBCb, 2010). It was the first plant in Europe to start volume manufacture of Hybrid vehicles with the Toyota Auris (Johnson, 2013). Up until this point, most hybrid vehicles in the UK were imported from the US or Japan.

Toyota Auris “Touring Sports” is a hybrid estate car. It is unique in being the only estate car to be equipped with a hybrid drive train and as such, there are optimistic predictions about the sales prospects for this variant (Johnson, 2013).

### 6.6.2 Toyota Electric Vehicles

Toyota (2011) has been experimenting with electric vehicles since 1971. Toyota (2011) also launched an electric variant of its iQ vehicle at the Geneva Motor Show (See also Aston Martin Case Study).

In international markets, Toyota is trialling an innovative electric vehicle, the i-Road (Lozanova, 2014), which offers a radically different take on urban mobility. The vehicle is an enclosed two seater, three wheeled vehicle, which uses 'active tilt' technology to achieve a narrow footprint, not much larger than a motorcycle on the road. This product offering is paired with an interesting mobility service business model. The value proposition offers the "convenience of a bike rental service, the comfort of an enclosed car and the compact footprint of a motorcycle". What is particularly interesting, is that the program already seems to be enjoying high adoption rates (Lozanova, 2014) and whilst the product has not yet made it to the UK marketplace, it is an interesting showcase of Toyota engaging with Business Model Innovation. What is particularly interesting, is the key partnerships that have been used to deliver this project, as have been set out by Martin (2014).

***Last year Toyota signed a Memorandum of Understanding with the city of Grenoble, the Grenoble-Alpes Métropole, car-sharing service operator Cité lib and French energy provider Électricité de France (EDF) to create a collaborative zero-emission ultra-compact urban car-sharing project.***

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**Martin (2014)**

Furthermore, it is interesting how digital technologies also have their part to play in this business model with Toyota having a "one mile mobility management" system (Martin, 2014) integrated into a smartphone app; furthermore, this system also integrates with a Hitachi designed bus information system (Martin, 2014).

### 6.6.3 Toyota Hydrogen Vehicles

Gerald Killman, European Projects director for Toyota, is quoted in Ebbs (2014) as saying that Toyota plans to bring fuel cell electric vehicles to Japan, the US and some European countries in 2015, depending on infrastructure availability. Previously, manufacturers developing hydrogen fuel cell vehicles had only offered them for lease because of their high development costs. When discussing

fuel cell vehicle technology in 2009, Michael Valvo quoted the price to lease vehicles from Toyota (£6000 per month) (Sunderland, 2009). However, since this interview, it is clear that there may have been a change in Toyota's business model; now offering fuel cell vehicles for purchase.

The cost of the vehicle is expected to be around ¥10,000,000 (£58,000) at current exchange rates (Ebbs, 2014) and initial sales are expected to be slow, however, Toyota hopes to gain some of the early mover advantage that they gained with the Prius in the Hybrid market. Sales are not expected to reach significant volume until the 2020's. Toyota have articulated a hope to reduce the price of Hydrogen vehicles to between ¥5,000,000 and ¥3,000,000 yen by the 2020's.

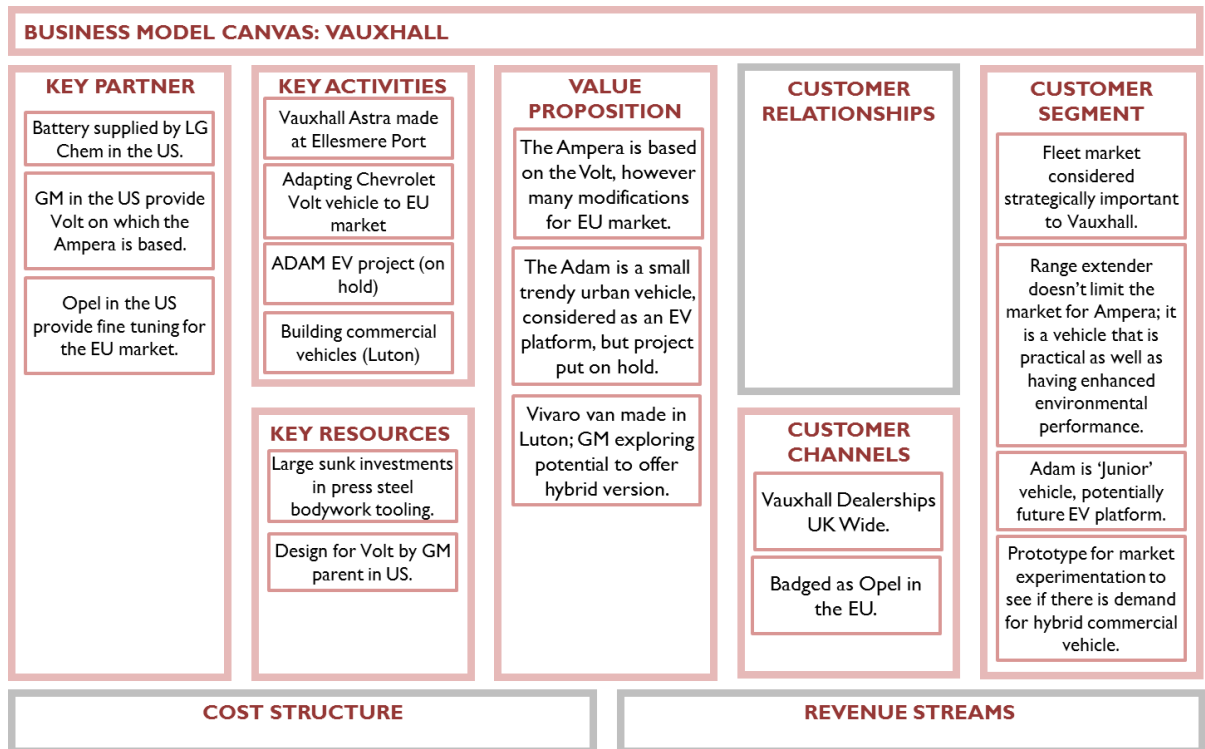
Whilst the FCV has been developed solely by Toyota, a Joint Venture with BMW has been announced to develop the second generation of fuel cell vehicles Toyota will launch (Ebbs, 2014)

#### **6.6.4 Acquisition of Shareholding in Tesla**

It was announced that in collaboration with Tesla, 35 vehicles would be built as part of a demonstration and evaluation programme through 2011 – with a vehicle ready for market in 2012; however Toyota stated in their press release that “*the business model, ha[s] not been finalized*”

Tesla is developing two battery electric ‘mules’ for Toyota, using their vehicles, with drivetrains designed by Tesla (Lucas, Tesla Toyota Partnership Takes Step Forward, 2010). Building on the success of Toyota's programme to lease RAV4 electric vehicles to fleets and private consumers in the State of California as part of the ZEV mandate; Toyota has decided again, to collaborate on an EV based on the RAV4 platform. This time, Tesla will supply the drivetrain (Lucas, Toyota and Tesla plan electric RAV4, 2010).

## 6.7 Embedded Case Study: Vauxhall



Business Model Canvas 10 – Vauxhall Business Model



Figure 93 – Vauxhall Ampera

### 6.7.1 Vauxhall Ampera

The Vauxhall Ampera range extender was the 2012 European Car of the Year (Holloway, n.d.) One of the novel features about the Ampera, is that the electronic control module only accesses 65% of the battery's usable power, this allows user experience to be managed as the battery degrades. Furthermore, to get around range anxiety, there is an additional four miles of "emergency mode" EV once the batteries and fuel tank are drained. Holloway (n.d.)

The European Vehicle has a number of variations compared to the American Chevrolet Volt, whilst the most obvious difference is in the external styling, the vehicle has been tweaked in other ways to suit the European marketplace

***There is now a team that has come together to do the final European tuning. There are some modes on this vehicle, that are Euro-specific. There is a mode where you can turn off the range extender completely, if you are driving into Amsterdam, or any city \* with electric-only drive, you can actually turn off the engine completely: tell it not to ever work. Any you have to make sure you don't run out of juice. You effectively go into the city with a full battery – you can go into mode whatever it is, and it will run completely electric in the zero emission area. But you see that is European-specific, they won't be doing it in the U.S. They can turn it on in the U.S., but they don't need it.***

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**Denis Chick, Vauxhall**

In 2009, General Motors announced that it had contracted "Compact Power" a US based subsidiary of LG to supply the battery packs for the Chevrolet Volt (Garthwaite, GM Officially Picks LG's Compact Power to Produce Volt Battery, 2009).

The fleet market is an important one to Vauxhall. Since the introduction of the MkII Vauxhall Cavalier, where Vauxhall were able to win market share from Ford's newly introduced, but unpopularly styled Sierra (Adams, 2014). What makes the Ampera appeal to this market, is that unlike EVs, the Ampera's range extender gives it the flexibility of a conventional vehicle, with some of the environmental benefits of an EV.

The UK is seen as the largest market for the Ampera in Europe (AWPresenter, 2010). In predicting the market share of ULEV vehicles (which is predicted to be 20% of the total vehicle market by 2020), Dr. Wolfgang Berhard sees much to recommend GM's strategy, commenting, "We see the range extender, and especially the simpler way that GM has pioneered with the Volt, as probably having the biggest share." Predicting that this configuration of vehicle could have 14% of the total market for vehicles by 2020 – comprising the greater share of the EV market (AWPresenter, 2010d).

Denis Chick reflects on the changes in customer channels through which vehicles are sold:

***Everybody is into innovation through trying to distribute information through the web; this is probably the most important way at the moment as the cost of advertising your products has gone up and up and up and up over the last ten years or so. Print is now a lot less of the marketing tool it used to be.***

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### 6.7.2 Vauxhall Adam

Vauxhall's Adam is another interesting development for the Vauxhall Business Model. It aims to compete against "urban chic" vehicles such as BMW's Mini, or Fiat's 500. Whereas these are retro inspired designs which draw inspiration from iconic vehicles, the Vauxhall Adam takes similar retro-inspired design cues but starts from scratch with the vehicle model brand.

There is a great deal of innovation in the customer relationship with a emphasis on individualisation:

***"No other car in this segment can be individualised as much as ADAM because we are offering virtually unlimited exterior/interior colour, fabric and kit combination choices. It's very unlikely that you'll find two identical ADAMs out there."***

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**Mark Adams, Vauxhall/Opel's Vice President of Design quoted in Reaney (2012)**

This degree of customisation and personalisation could make the ADAM attractive to young buyers, and help Vauxhall compete as an increasing number of customers from their middle-ground segment migrate to either value offerings or premium compact offerings. In the interview with Denis Chick, conducted as part of this research, the impact these changes are having on the business model is seen:

***If you look at the Vauxhall website now it is pretty sophisticated, you can do your own car design, colours and all the rest of it.. pricing, comparisons – you can even order a car, we have internet buying on our site – we started this in 1997. {...} The innovation now, I think, is coming in the way we market rather than the way we manufacture or distribute.***

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**Interview with Denis Chick, GM**

What is also evident to a degree in this quote, is the degree to which this reaffirms the view that some parts of the automotive business model are considered unchangeable. Namely the value creation side.

The Adam also had the potential to be a very exciting platform for Electric Vehicle development. There were originally plans for an Adam Electric Vehicle, which was originally to have made use of the drivetrain of the Chevy Spark (Couts, 2011) under development by parent company GM. The fusion of the Spark's ULEV drivetrain, with the Adam's innovative management of the customer relationship



.....Edelstein (2012) cites Dieter Metz, chief engineer for the Adam, “We could not charge the customer the price needed to make it work on the cost side,”.

This raises the question as to whether business model innovation could have spread the costs of the vehicle?

### **6.7.3 Vauxhall Commercial Vehicles**

Vauxhall also produced a range of commercial vehicles at its IBC plant in Luton. With its roots in the Bedford vehicle marque, the IBC plant later produced vehicles under a joint venture between Isuzu and Vauxhall. In 1998, GM bought Isuzu out of the partnership. In more recent years, the plant produces commercial vehicles on a shared platform between GM, Renault and Nissan.

Vauxhall have also announced a Vivaro e-Concept range extended electric van (Lucas, 2010). This echoes the concept of “business modelling” (discussed in the BMW MINI embedded case). As Chris Lacey commented to Lucas (2010) the concept was to “test acceptance of advanced propulsion technology among the commercial vehicle specialists”

It has been announced that the next generation of Vivaro will be manufactured at the Luton Plant. (Roberts & Warburton, 2013).

## 6.8 Chapter Summary

Chapter Six was a case study comprised of seven embedded cases, in the category of what has been termed ‘TNC (Trans National Corporation) / MNC (Multi National Corporation)’ vehicle manufacturers’. As was discussed in Chapter Four on methodology, there was a significant challenge in deciding how to categorize the embedded case studies – with some firms such as ‘Aston Martin’ and ‘Rolls Royce’ being challenging to allocate to a set.

It was decided in Chapter Four that for methodological simplicity, the cases would be grouped into two-sets, TNC and SME vehicle producers. It could have been argued to introduce a third intermediate group of lower scale premium vehicle manufacturers.

As discussed in Chapter Four, ultimately there is a degree of subjectivity in allocating cases to arbitrary sets. Due to the scale of firms, there was already a much smaller number of ‘embedded cases’ of firms, than in the contrasting case of SME vehicle manufacturers to follow.

On the production side of the TNC vehicle manufacturers business model, it could be seen how there was a degree of uniformity and homogeneity in the way that large car producers manufacture vehicles. There is a consistency in the way that processes such as pressed steel are used for chassis and bodywork. One of the things that could be distinguished between the “premium” vehicle manufacturers examined in the case and the other manufacturers – and perhaps something which could have contributed to the argument for a third case, is that with premium vehicle manufacturers, there is a growing use of aluminum for vehicle weight reduction. That said, in sustainability terms, this represents a modest improvement as premium vehicles are by their nature already bulky and heavy.

On the customer-facing side of the business model, there is also a great degree of similarity on how the elements of the business model are organized, with the centralized production resulting in long international supply chains to the customer and dealer networks.

The case also highlights how TNC’s are starting to approach business model innovation. The case provides evidence for how TNC’s are using small projects to “test and refine” business models.

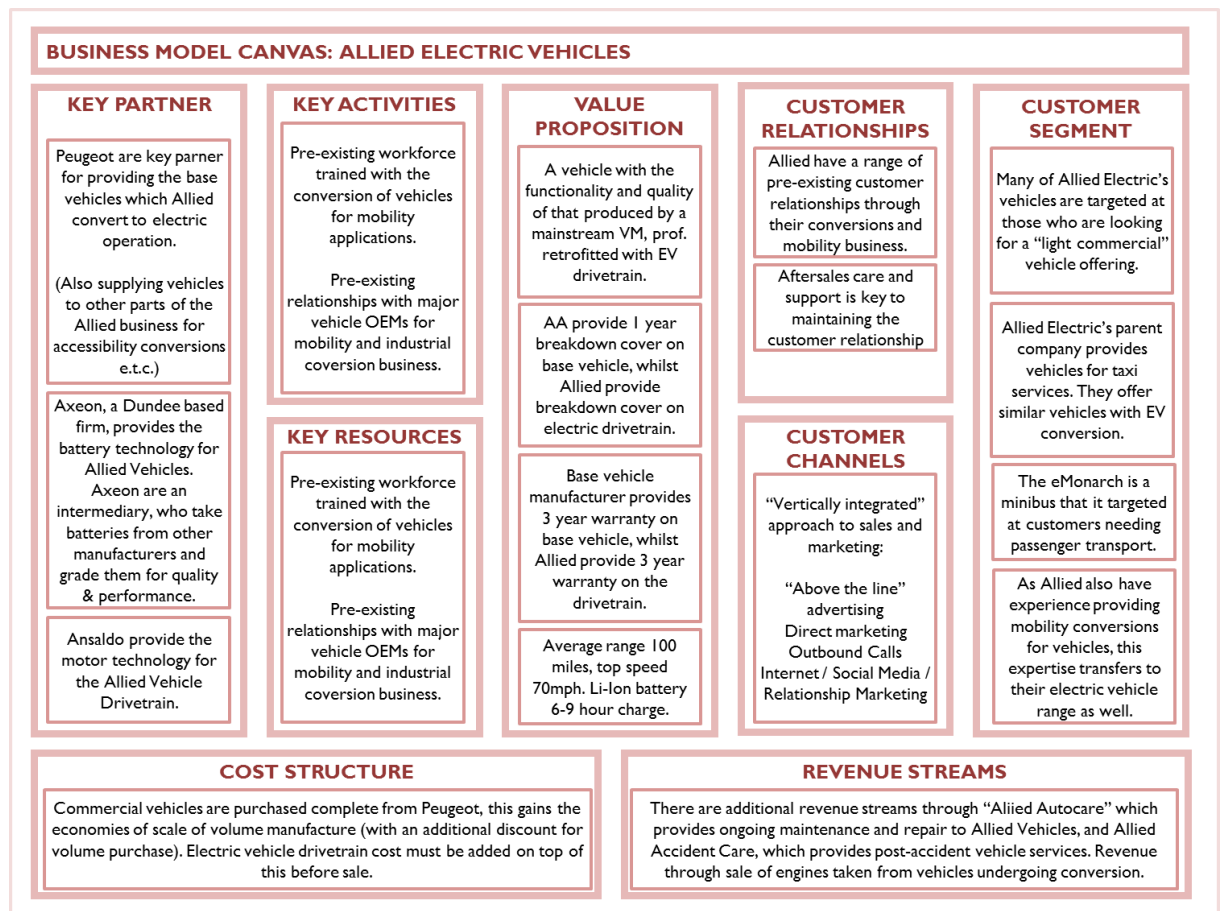
## Chapter 7:

### Case Study II- SME Vehicle Manufacturers

Timmers, (1998), in referring to new business models enabled by new technologies, highlights that *“many of the conceivable models have not yet been experimented with commercially”*. Whilst small and perhaps inconsequential on the scale of the global industry, the freedom to experiment that SME vehicle manufacturers enjoy suggest that this scale of operation may be the ‘sandbox’ for new business model development and experimentation.

One of the common themes is how the opportunities offered by ULEV vehicle development have offered new contexts to existing SME VMs. It can be seen in the embedded cases of Ginetta, Lotus, Morgan and Westfield how companies with business models based on the production of low-volume, SME vehicles have begun the process of investigating how the **‘KEY ACTIVITIES’** currently carried out by their businesses may be transferable to the domain of ULEV production.

## 7.1 Embedded Case Study: Allied Electric Vehicles



### Business Model Canvas II - Allied Electric Business Model

#### Key Statistics:

- £74 million annual turnover
- 20 Acre Manufacturing Site
- 100,000 square foot assembly plant
- 410 strong workforce (Allied Vehicles).

Allied Electric (Allied) is part of the Allied Vehicles Group which has grown to employ 410 people since the business was established in 1993 (Sunderland, An interview with Allied Electric, 2010). One **CUSTOMER SEGMENT** which Allied Vehicles Group has focused on is adapting vehicles for those who require accessible transport. Through focusing on commercial vehicles, Allied Electric has targeted businesses and public sector organisations as potential customers.

Allied Electrics **VALUE PROPOSITION** is based on converted Peugeot vehicles. Allied Vehicles Group had a pre-existing relationship with Peugeot, adapting their vehicles for certain niche markets with this relationship being extended for Allied's range of LCVs.

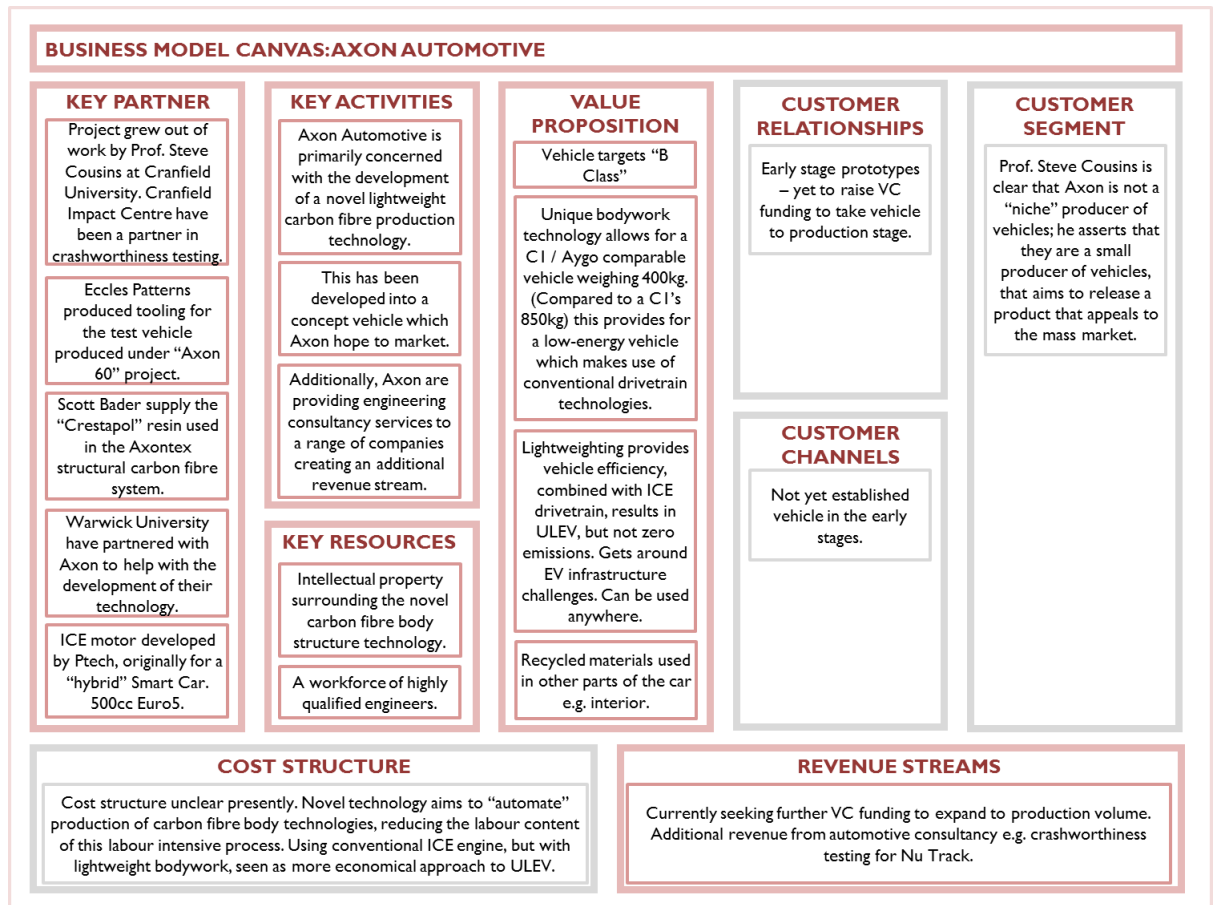
In terms of **KEY PARTNERS**, the battery technology for Allied's range of vehicles is supplied by Axion in Dundee, and some research and development has been carried out in partnership with Strathclyde University, a local partner.

The **COST STRUCTURE** of the business is based around buying vehicles in volume (at a discount), recovering some of this cost through the sale of engines and unused equipment removed during the conversion process. On top of the cost of the vehicles is the drivetrain and labour required for conversion. Allied Electric's vehicles are priced from £40,000 and when questioned by Sunderland (An interview with Allied Electric, 2010) Nelson believes that this is within the means of ordinary businesses; it is worth mentioning here that the **CUSTOMER SEGMENTS** Allied targets are almost exclusively commercial customers.

In talking about future plans (Sunderland, An interview with Allied Electric, 2010) Nelson stresses the need to look out for new and emerging technologies with the need for technological innovation being recognised explicitly,

One of the questions the report on Low Carbon Vehicles for the Scottish Executive (Atkins Ltd, 2009) was commissioned to answer was whether Scotland's automotive industry should focus on particular vehicle types? The report explained that the current focus had been on the bus and small van sectors. *"It would appear that current business models have justified this investment. It would make sense for the Scottish industry to focus on specialist vehicles, such as buses, mini buses, and small vans given that they are already developed in these fields. However there are many parts within the supply chain and companies such as Axion have already demonstrated an ability to provide parts for a wide range of vehicles. It is therefore essential that existing, new, and emerging industry sectors do not limit their aspirations."*

## 7.2 Embedded Case Study: Axon Automotive



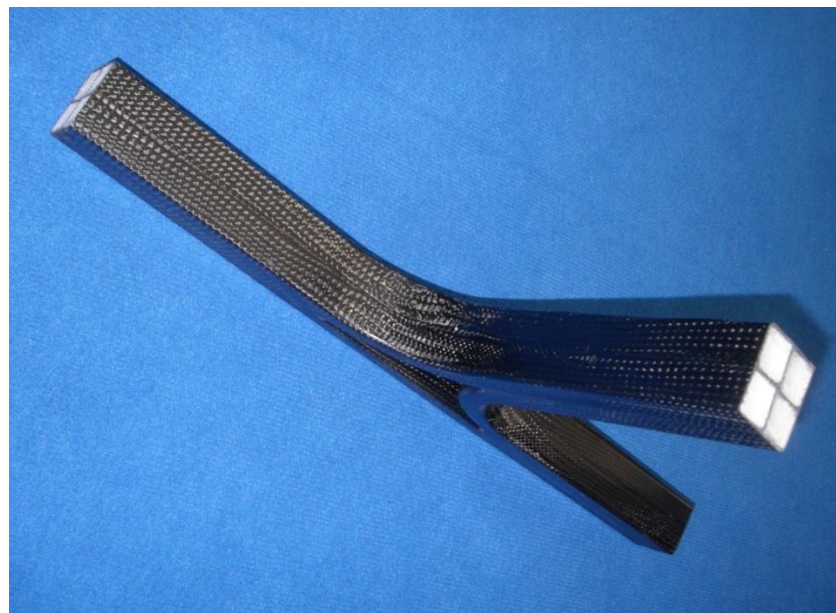
**Business Model Canvas 12 - Axon Automotive Business Model**

Date	Event
Dec 2005	Axon Automotive incorporated as a limited company
Jun 2009	Secures £2.5 million brokered by Cambridge-based TTP's carbon trust incubator. Over £2m of current funding from the Technology Strategy Board
Oct 2009	Prototype previewed at Milton Keynes Science Festival
Sep 2009 – Feb 2011	Axon 60 Project, under Cranfield Impact Centre, used TSB funding to test crashworthiness of carbon fibre monocoque built using Axontex technology.
2012	Axon E-PHEV launch date
April 2012	Axon receives JEC Composites "innovation Award"
April 2012	Scott Bader (Key Partner) receives JEC Composites "Partnership Award" for work with Axon.

References: (Green Car Congress, 2009) (Companies House, 2012)

Axon Automotive grew from the ideas of Steven Cousins, formerly a Professor at the Honda Eco-Technology centre at Cranfield University. Whilst at Cranfield, he specialized in composite materials, working on a variety of automotive body technologies – working on recycling carbon fibre from Fighter jets into new second-life products for the automotive industry (Kewney, 2008).

When used in automotive applications, carbon fibre is traditionally used in either sheet form, or in the form of tubes and structural members. Axon's proprietary technology is unique in its field. The key piece of intellectual property that differentiates Axon from the competition, is a unique method of producing lightweight bodywork. This consists of a foam core, around which carbon fibres are wrapped. The company initially developed four products using its unique structural material "Axontex" ; "a piano, a go-kart, an ice pick and a car chassis" (Design Council, 2007)



**Figure 94 - Close up detail of Axon Automotive's novel carbon fibre chassis technology - where carbon fibre surrounds a lightweight core of polystyrene.**

This lightweight body shell is married to a hybrid drivetrain which employs an ultra light 500cc all-aluminium engine developed by a Norfolk based company, Ptech (Kewney, 2008). In questioning Professor Cousins about the choice of technology pathway, he explains how the plug-in hybrid drivetrain circumvents many of the infrastructure problems associated with electric vehicles; however, announcements in April 2010 since the interview was conducted (Autoweb, 2010) indicates that Axon has entered into a strategic partnership with E-on as part of the Milton Keynes Plugged in Places bid.

Thought has also been given to sustainability in other aspects of the vehicle, with the seat covers being made from recycled jeans and pin-stripe suits (Kewney, 2008). This is a touch which may help in marketing the vehicle to eco-conscious consumers.



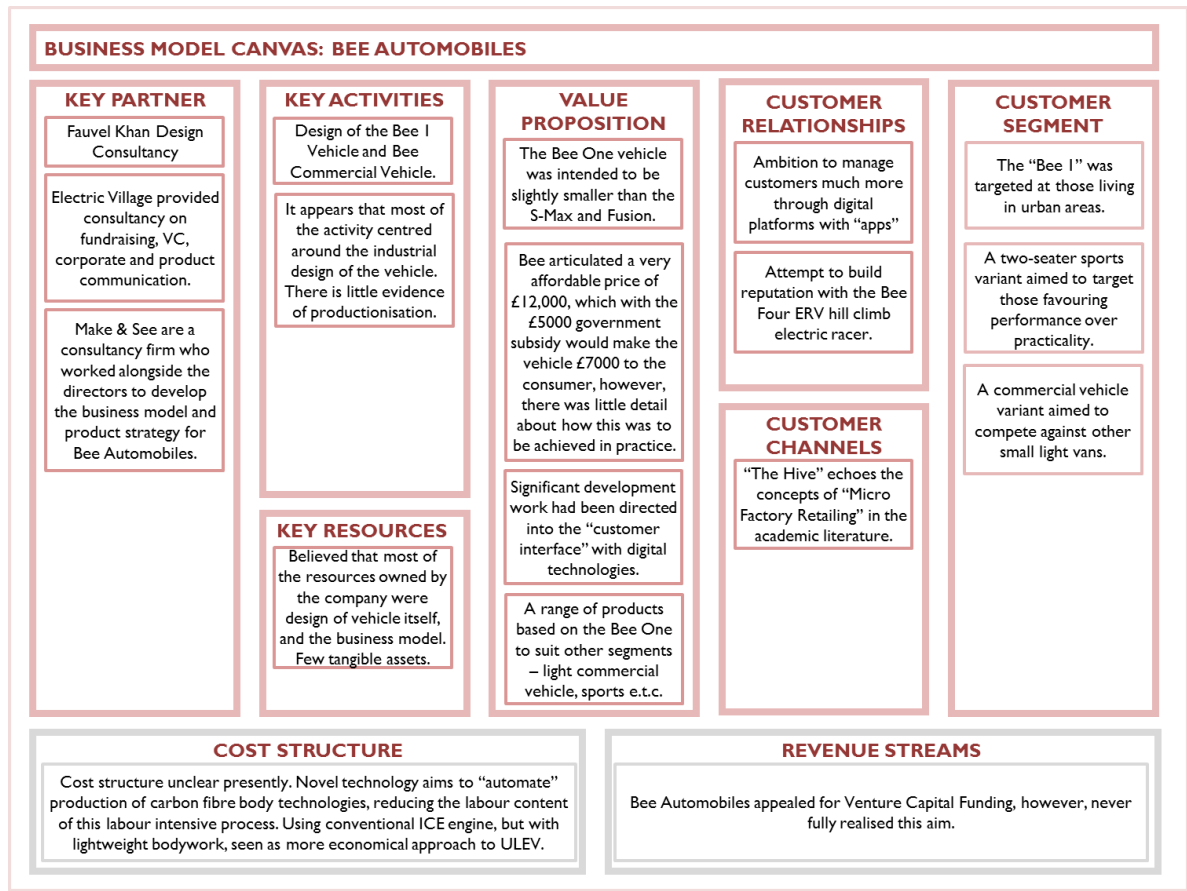


**Figure 95 - Front end, with body panels removed, of Axon Hatchback. Note extensive use of carbon fibre, and novel chassis technology.**

A budget of £1.4million was required to develop the prototype vehicle, 40% of which was financed with a £650,000 Energy Saving Trust grant (Design Council, 2007). One of the advantages of the Axontex material's design philosophy, is that it doesn't require the massive up-front investment costs associated with the pressed sheet bodywork, which makes the technology viable for much smaller production runs; Steve Cousins *"Tooling costs of a new design steel car are around £100m [...] We're a fraction of that, which is why we can get started with quite small production runs."* Axon's business model can be seen to be borne out of a design-led strategy (Design Council, 2007).

They hope to go to market with a price of £10,500 for the basic vehicle (Kewney, 2008).It was reported that in the first year of operation, Axon had a turnover of £700,000 (Burn-Callander, 2008) Scott Bader have been one of the Key Partners of the Axon project, they are a chemical company which supplies the "Crestapol" resin, which has been designed to be "vacuum infused" into the Axontex body technology.

## 7.3 Embedded Case Study: Bee Automobiles Ltd.



Business Model Canvas 13 - Bee Automobiles

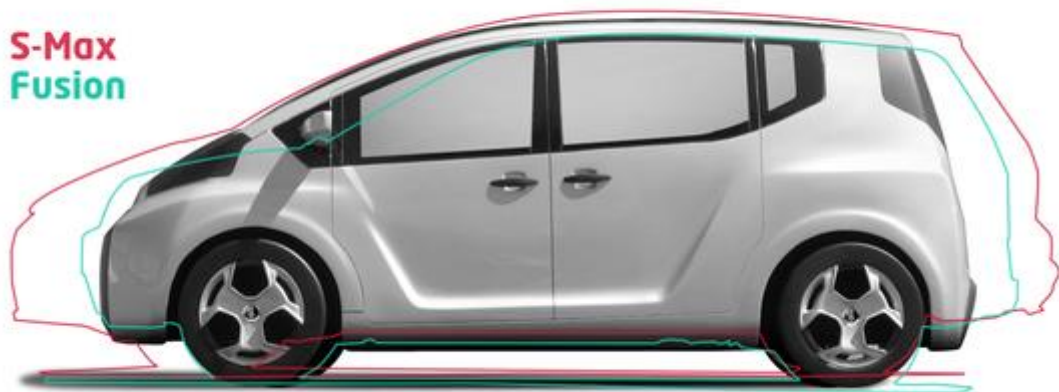


Figure 96 - Bee Automobiles, Bee One

Bee Automobiles was an endeavour to develop a new business model and product strategy for bringing an electric vehicle to market. Whilst ultimately, the project proved to be a failure and no vehicles

were produced, the company is an interesting embedded case as it shows evidence of entrepreneurs in the UK looking at business model designs that could challenge the conventional automotive industry.

<b>Date</b>	<b>Event</b>
<b>August 2008</b>	Bee Automobiles Ltd. Incorporated at Companies House <sub>1</sub>
<b>2010</b>	Bee Automobiles Ltd. dissolved <sub>1</sub>
<b>June 2010</b>	Project placed into 'stasis' after securing finance proved difficult.
<b>2011</b>	Bee hoped to produce 12,000 vehicles.

(Companies House, 2011)

Bee Automobiles Ltd. is a venture that was set up to develop the lightweight “Bee1” car and “BEE LCV” lightweight commercial vehicle. The company was registered with Companies House (2011) with ambitious plans with its registered SIC codes being:

- 3110 - Manufacture electric motors, generators etc.
- 3140 - Manufacture of accumulators, batteries etc.
- 3410 - Manufacture of motor vehicles
- 7222 - Other software consultancy and supply

The company was founded by Stephen Voller, who previously had experience in information technology, having been a serial entrepreneur who was a semi-finalist in the Ernst and Young Entrepreneur Awards 2006, Voller had successfully brought to market a compact energy storage solution based on fuel cells and sought to build on this to introduce a vehicle to the marketplace.

Bee Automobiles was founded in August 2008 and the project effectively ran until June 2010 when the project was placed into “stasis” as it proved hard to source the requisite finances to develop the company further amidst the global recession of 2008. The concept even appeared on the BBC TV series “Dragon’s Den” (BBC, 2011) attempting to raise £2.5million, the largest amount ever requested on the show.

In terms of the technical design of the vehicle, there was a move to use off-the-shelf components from existing manufacturers for body trim, keeping costs low. Techniques such as using “buttresses” enabled the new vehicle design to accommodate the windscreen from an existing small vehicle, and reducing tooling costs. The power train focused on eliminating the gearbox, using twin motors for drive. The

top design speed was 80mph with acceleration 0-80 in 10 seconds. The vehicle was designed to cover a 100 mile range at an average speed of 56mph.

The manufacturing model for the vehicle centred around 'the Hive', envisaged as a micro-factory retail outlet which would both manufacture the vehicle and provide after sales support. The project was placed "into stasis" before detailed plans for the configuration of the hive were developed. However, it was envisaged that the vehicle would be based upon an aluminium chassis and produced using production methods suited to smaller scale production with a high degree of customisation. If finance had been forthcoming, an initial production volume of 12,000 vehicles was scheduled for 2011.

In the short to medium term, the marketing strategy revolved around the concept of selling the Bee as a second vehicle to existing vehicle owners, as a substitute for short, polluting journeys. In addition, to target the commercial market it was envisaged that a "small van" variant would be rapidly developed. With the ongoing trend towards higher oil prices, Bee anticipated a greater demand for smaller more fuel efficient vehicles in the longer term.

Bee planned to add value to the customer experience through modularity and customisability, basing the configuration of the interior modules around a "floor rail" system which allowed for easy exchange of different components to customise the vehicles for different purposes. Every Bee would be "built to order", with customers 'designing their vehicle to specification' using an online interface where customers could pick from a range of variations. A prospective customer could go online, design their vehicle and then decide whether to purchase.

This experience would be managed through a dedicated piece of customer relations management software. Developing this custom software was part of Bee's ambition as a company; as it was envisaged that this CRM software would be very valuable to others in the automotive industry and could be sold as a "white box" solution to other manufacturers. The customer relations management system would consist of three components: a black box fitted to the vehicle that would report on vehicle status and activity, a web portal for Bee customers to manage their vehicle using an online

interface and a dedicated server solution to manage the interaction between the vehicle, consumer and Bee. Bee list the benefits of this service as offering improvements to:

- Safety
- Power monitoring
- Downloads and upgrades
- Future proofing
- Personalisation and configuration
- Contact me services
- Integration and presentation

It was envisaged that owners of Bee vehicles would form a community of owners, which could in turn be leveraged in promoting the vehicle. In return for concessions, owners might receive an update electronically about someone in their area who was interested in purchasing a Bee and, in return for acting as a “brand ambassador” and showing the person their vehicle, they would receive benefits or payment from the company.

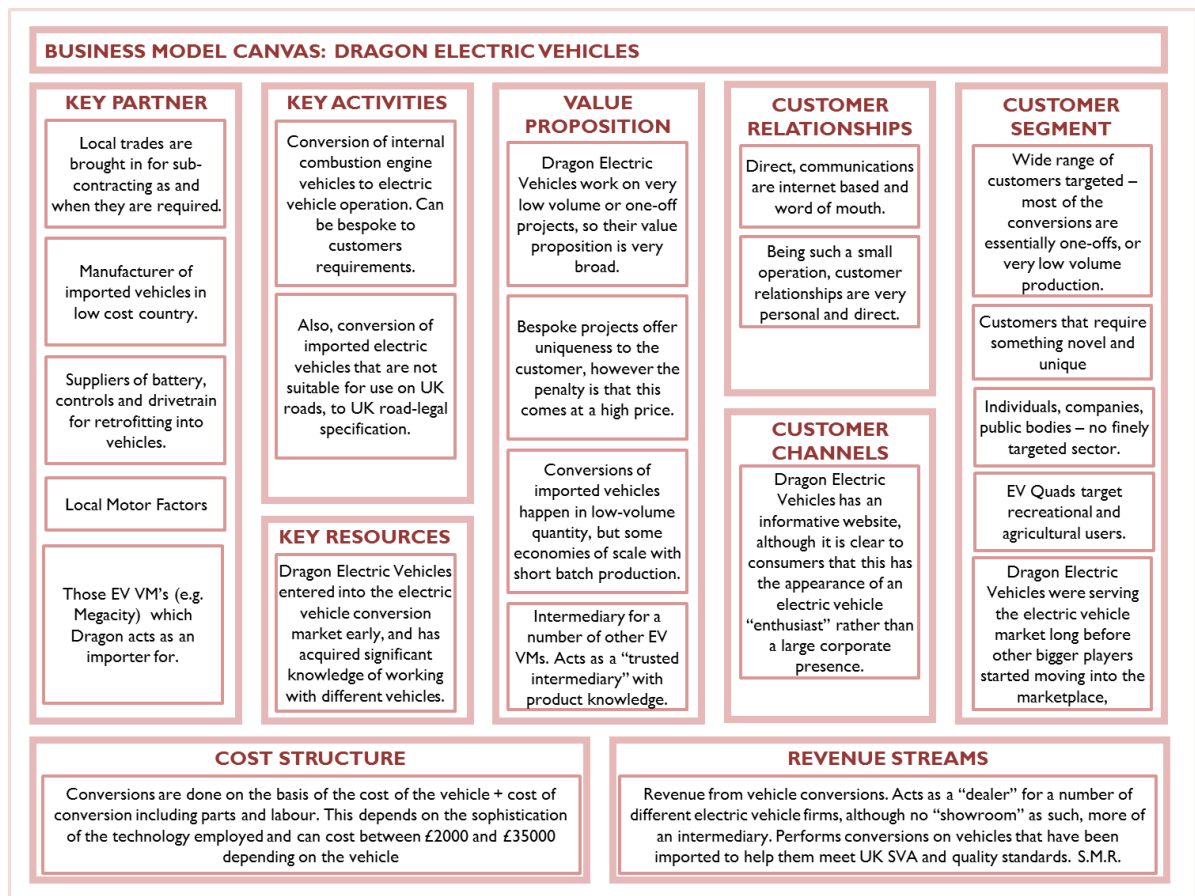
Bee automotive plan to manage the customer experience directly, with customers coming to a central location “the Hive” for sales, servicing and aftercare.

There would also be extensive use made of new communication methods to manage the customer experience. In part this would be facilitated by sophisticated on-board electronics, with the vehicle able to “text or email customers when the vehicle required servicing or repair”

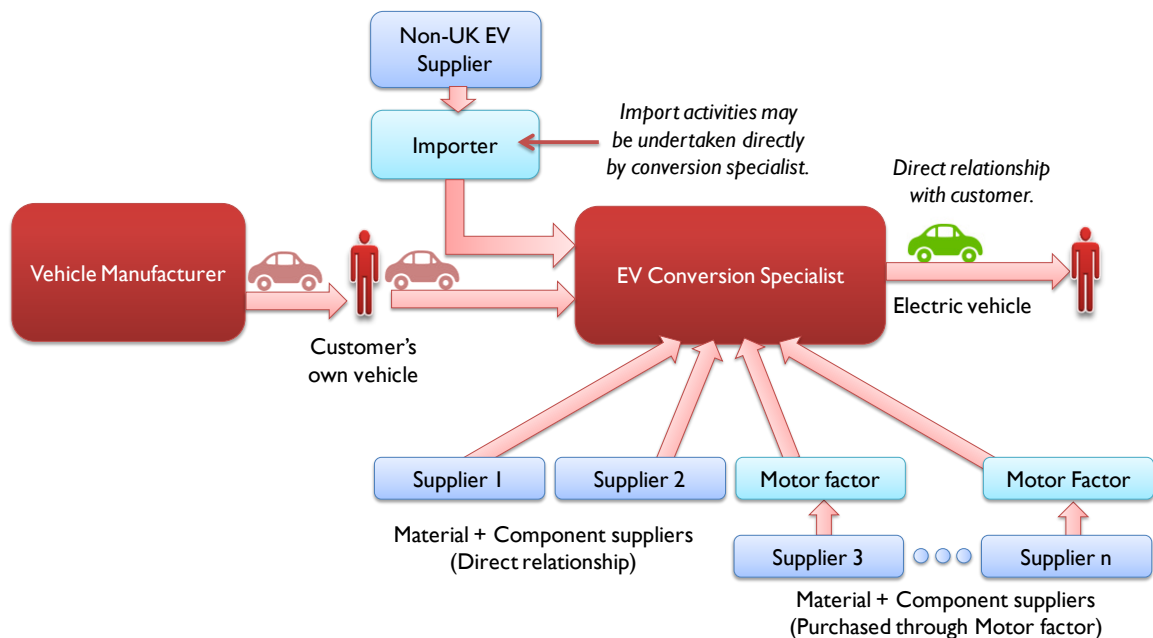
As can be seen, the Bee Automobiles business model is one that has been enabled by information and communication technologies, (Timmers, 1998, p. 2) and many of the core components are novel, of their time and would not have been possible before the advent of widespread ubiquitous ICTs.

Whilst edited for entertainment, rather than for serious research, the appearance of Bee Automobiles CEO on Dragon’s Den gives some degree of insight into the business community and entrepreneurs attitude towards start up vehicle companies.

## 7.4 Embedded Case Study: Dragon Electric Vehicles



**Business Model Canvas I4 - Dragon Electric Vehicles Business Model**



**Figure 97 - Diagrammatic Representation of EV Conversion Specialist Business Model Archetype**

Dragon Electric Vehicles is a small operation, based in Cwmdru outside Crickhowell, Wales; which converts electric vehicles. Essentially a one-man operation, with additional work sub-contracted out to specialists, Dragon converts vehicles to electric operation. Customers supply conventional vehicles for conversion and then Dragon develops a bespoke specification based on the customer's needs. Furthermore, Dragon also sources some electric vehicles made in low-cost economies and brings them up to the standards required for UK homologation.

It is a small business, which produces vehicles in the tens, rather than hundreds of thousands – however, it has been an early component of the UK's transition to ULEVs, and has developed the niche long before other companies entered the business.

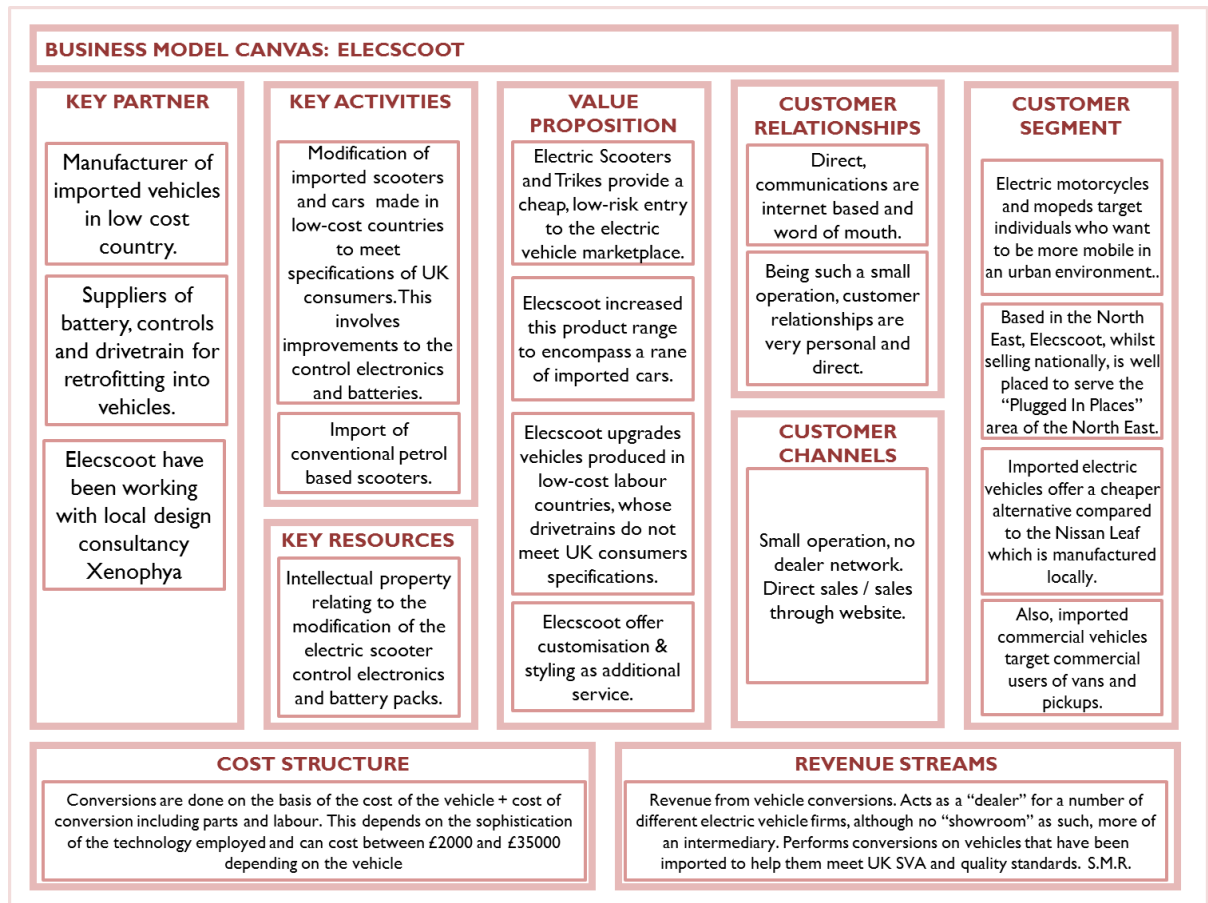


**Figure 98 - An electric vehicle being refurbished by Dragon**



**Figure 99 - Chinese Manufactured Off-Road Electric Recreational Vehicle**

## 7.5 Embedded Case Study: Elecscoot



**Business Model Canvas 15 - Elecscoot Business Model**

Elecscoot (Elecscoot, 2010) are a company based in County Durham which retails electric scooters, trikes and quad bikes to the public. Elecscoot also has a business selling petrol scooters and it is believed that this side of the business will continue for some time to support the business financially and provide additional revenue streams. Since the interview was conducted at the beginning of the research, it has been noted that Elecscoot have grown to also import small electric cars and also commercial vehicles (Elecscoot, 2014).

The company imports scooters from a number of suppliers in China. The business started by simply importing vehicles from China from a small number of **KEY SUPPLIERS**. After initially importing vehicles from China for resale in the United Kingdom, it was found that a high level of customer dissatisfaction arose from poor quality control componentry and battery systems not suited to the expectations of the UK consumer. As the market for imported products from China grew, so did



consumer awareness that in many cases these products were unable to meet expectations, often fail prematurely and would often underperform.

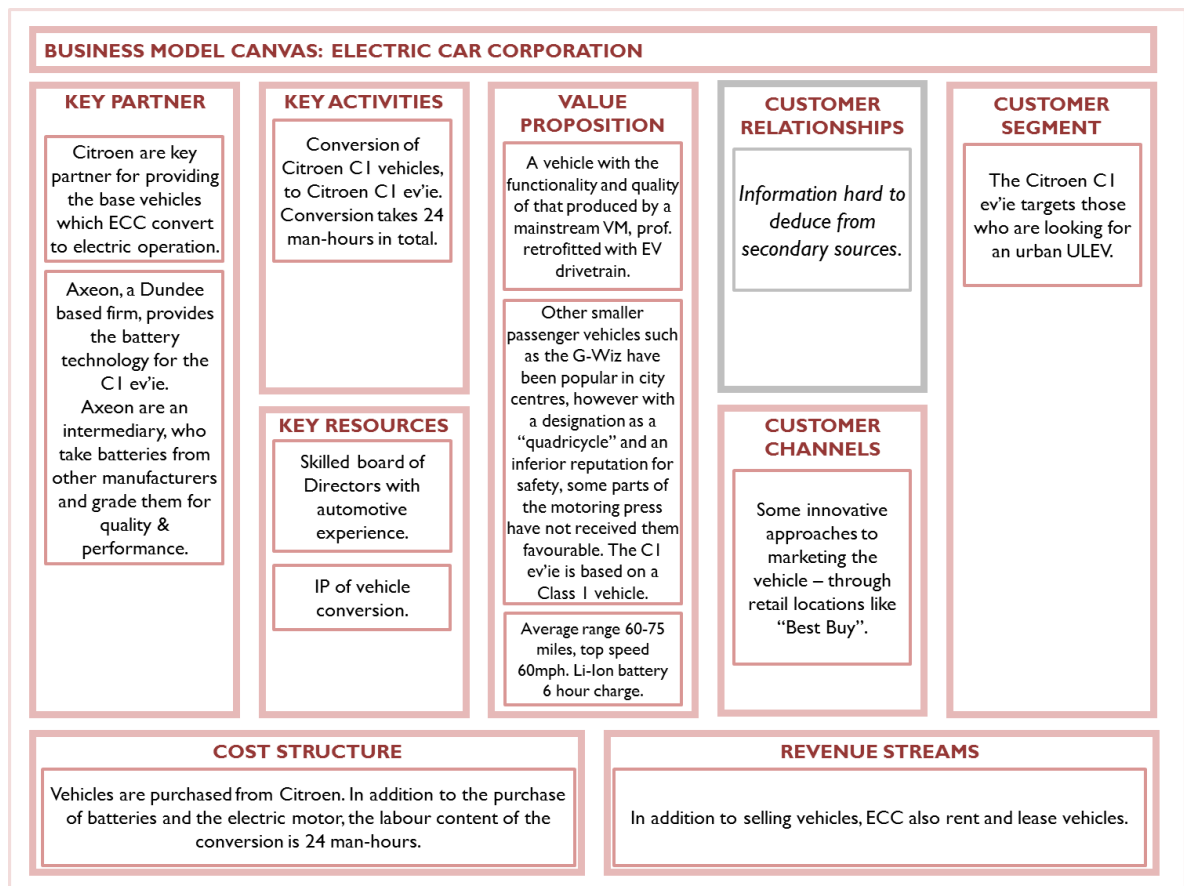
Elecscoot identified an opportunity to add value to these products. Whilst consumers had confidence in the quality of the chassis, bodywork components, trim and drive system of these imported scooters, an opportunity existed to improve the reliability of the electric drivetrains and in some cases upgrade performance through enhanced battery technologies. Elecscoot worked to develop its own drivetrain technology and now remanufactures the scooters by adding its own proprietary batteries and drive electronics according to customer specifications.

The drivetrain controllers and battery technology are sourced from external suppliers, however, the information regarding systems integration is intellectual property of Elecscoot. At the moment, this intellectual property is managed informally. The batteries by far represent the largest expense in the scooter (re) manufacturing process.

Additionally, Elecscoot have found that value can also be added in the process of (re) manufacturing, by giving consumers some choice over customisation of the scooters. There is a limited degree of customisation available, but this takes the form of "respraying" the bikes as imported or detailing - it is important to differentiate this activity as value that Elecscoot adds rather than customisation at the point of manufacture. In addition, Elecscoot have been working with local design consultancy "Xenophya" (Xenophya, 2008) to offer additional design flair to their products.

Since the primary data was collected, it has been found that Elecscoot have built from this base, to sell a range of imported electric cars; quite a range of products are offered on their site. The "City Plus" is what would be called a "Shanzhai" product in China – that is to say, a product that is made cheaply, but whose exterior appearance closely resembles that of a brand leader. Looking at it, it is clear that it bears a more than passing resemblance to a BMW MINI but at a much lower price tag. It is interesting to see how the progress of Elecscoot mirrors that of some early car manufacturers, graduating from selling motorcycles, to producing road vehicles, an interesting business model evolution.

## 7.6 Embedded Case Study: Electric Car Corporation



**Business Model Canvas 16 - Electric Car Corporation Business Model**

The story of the C1 Ev'ie's development, begins with the 'B-Zero' project; a collaboration between PSA Peugeot, Citroen and Toyota, with the product of the joint venture a small city car which is marketed as the Citroen C1, the Peugeot 107 and Toyota Aygo respectively; the car has been in production since 2005 at a plant in Kolin, Czech Republic.

The Electric Car Corporation is a Public Limited Company, incorporated on the 22<sup>nd</sup> February, 2010. (Companies House) which produces a remanufactured Citroen C1 electric vehicle. Hill, Hazeldine, von Einem, Pridmore, & Wynn (2009) cite the C1 Ev'ie as one of the first 'volume manufactured EV's' with supporting statistics from Stephens (2009) that ECC anticipate producing around 500 C1 Ev'ies (taken to be May 2009-2010) rising to between 2,000 and 4,000 units in 2010 from its Bedford based factory which employs a six-person team (BBC, 2009)

This is a project which appears to be with Citroen's blessing as (Stephens, 2009) quotes Xavier Duchemin, managing director of Citroën UK, said: *"We are committed to providing greener alternatives for motorists and are delighted to be supplying ECC with CIs for this exciting project."*

A clue to the use of the Citroen CI as a platform can be found in an article by (Der Spiegel, 2007), which found in petrol cars currently on the marketplace, the CI had the second highest fuel economy; second to the Toyota Prius. By starting with a vehicle that is inherently small and economical, ECC have managed to achieve a vehicle that is the first production electric four-seater in the UK (Parrott, 2009). The conversion from CI to CI ev'ie takes 24 man-hours of labour (Schwoerer, 2009b).

found on ECC's website as they boast that their vehicles are *"based on safety proven EU platforms that have been fully crash tested and have full air bags and other passive and dynamic safety systems."* (What Car, 2010) also notes that out of a trial of electric cars, the Ev'ie is notable for the high standard of its interior as it is based on a standard production car. In choosing, as part of the business model, to develop a car based on an existing production model, ECC have bridged the gap between consumers expectations of existing vehicles and electric vehicles – as described by (Modified Cars, n.d.) it doesn't 'scream electric when you look at it' – by producing a product that isn't as 'alien' to consumers when compared to other more utilitarian electric vehicles in the same class.

It is interesting the degree to which technology has been retained from the original vehicle – the five-speed gearbox from the manual CI is retained, albeit fixed in third gear (Parrott, 2009).

However, despite the extensive input of technology from a donor vehicle, there is still value to be gained from this business model, as ECC are quoted as saying that "more than 50 per cent of the value of each model originates from the UK assembly" (Stephens, 2009) presumably also a reference to the supply of batteries from Dundee based Axion (Axion, 2010)

*"shareholders and directors of ECC have many years of experience within the motor industry and with dealing with public sector/private sector partnerships to create infrastructure to stimulate the use of new technologies"*

One of the aspects of ECC's business model, is how their vehicle is marketed and sold. The following is a photograph taken in "Best Buy Thurrock" mid 2010.



**Figure 100 - Citroën C1 Ev'ie (Adapted by Electric Car Company) for sale in Best Buy Retail Store Thurrock**

The Ev'ie reached the UK marketplace at a time when the alternatives in the 'small cost-effective electric vehicle' segment were of a much poorer quality, a review for Autocar (Parrott, 2009) describes thus "Given that your only other options are the extraordinarily undesirable and impractical G-Wiz, or the barely more acceptable NICE Mega City, the Citroen C1 Evie is a no-brainer."

By starting with a production vehicle, ECC were able to reduce the development costs of bringing a new vehicle to market, enjoying the benefits afforded by using a production vehicle as the base and creating a product which which economical helped consumers by making it an "infinitely more palatable segment to shop in." (Parrott, 2009)

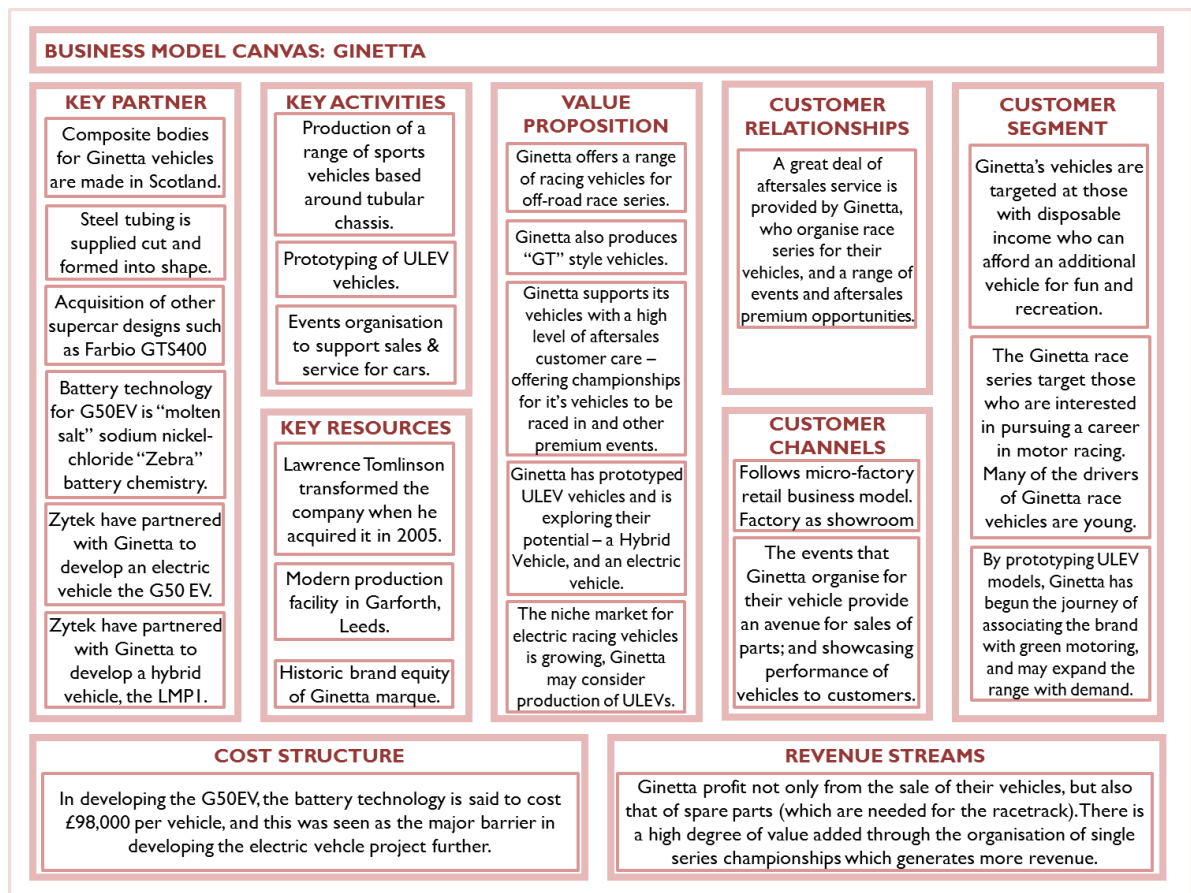
### 7.6.1 Inductive Power Charging



**Figure 101 - Citroen C1 ev'ie fitted with Halo IPT Inductive Power Transfer**

ECC have also been involved with a firm Halo IPT to trial inductive charging technology. This could significantly improve the value proposition for the vehicles in urban environments. There is some concern that in urban environments, charging cables could create health and safety hazards, or even be a target for vandalism. Research has been ongoing, involving Oxford Brooks University to validate the efficiency of Inductive Power Transfer, vs. Plug In technology. (SVEC, 2011)

## 7.7 Embedded Case Study: Ginetta



**Business Model Canvas 17 - Ginetta Business Model**

Ginetta is a marque that has been established since 1958, when four brothers founded a firm to produce the GI vehicle, based on a Wolseley Hornet. Over a period of around five decades, Ginetta built a business based on producing both kit-cars and limited production cars based on vehicles of the day. In the main, these vehicles were sports cars (with the notable exception of the GRS estate car). Ginetta was in turn acquired by a group of businessmen in 1989, but the most significant turning point was in late 2005, when Ginetta was acquired by Lawrence Tomlinson, a businessman who made money in other non-automotive ventures. Tomlinson bought Ginetta, and set about a programme of investment to transform the company. As the timeline overleaf (Table 21) shows, Ginetta has a history and heritage that Tomlinson has built on – however, the business model of the company has been significantly changed in recent years. In addition to the production of vehicles, there is a strong customer service element to the business; providing experiences and race championships for the vehicles. This supports the sale of vehicles and generated additional revenue streams.

<b>Date</b>	<b>Event</b>
<b>1958</b>	Ginetta founded in 1958 by four brothers Bob, Ivor, Trevers & Douglas Walklett in Suffolk
<b>1958</b>	Ginetta's first vehicle, the 'G1' based on pre-war Wolseley Hornet <sup>1</sup>
<b>1958</b>	Ginetta's first 'production' car the G2 produced as a 'kit' based on tubular steel chassis and aluminium bodywork. Running gear taken from Ford components.
<b>1959</b>	G3 introduced – bodywork changed to fibreglass. G4 introduced retaining combination of lightweight steel and glass fibre. Ginetta introduces GRS – notable in that the vehicle is a large estate car – atypical from the sports cars offered to this point.
<b>1962</b>	Ginetta relocates to Witham, Essex
<b>1964</b>	Ginetta produces a Formula Three racing car based on a monocoque glassfibre chassis.
<b>1972-1974</b>	Ginetta operates from larger premises in Sudbury, Suffolk
<b>1974</b>	Ginetta returns to Witham, Essex
<b>1989</b>	Ginetta leaves Witham after being bought by an international group of enthusiasts, headquarters in Sheffield. Ginetta moves to Scunthorpe. Company offers vehicles in both kit form, and also as complete limited production vehicles.
<b>2003</b>	Ginetta introduces Junior Ginetta Championship
<b>Late 2005</b>	Ginetta acquired by LNT Automotive
<b>Mid 2007</b>	Ginetta moves to new state-of-the art factory in Leeds
<b>2009</b>	John Surtees drives Ginetta G50 EV the length of the Channel Tunnel – the first production car to do so. <sup>3</sup>
<b>January 2010</b>	Ginetta announces plans to put the G50 EV into production have been put on hold after failing to secure £1.7million government funding.
<b>March 2011</b>	Ginetta acquires Farbio rebranding their car the Ginetta F400
<b>March 2011</b>	Ginetta releases G55
<b>2011</b>	Ginetta announces GT Supercup for G55 vehicles <sup>4</sup>

(Georgano, 2000)

(Williams, 2009)

(Ginetta Cars, 2010)

**Table 21 - Timeline of Ginetta Cars Development**

Each new model starts with the origination of a design, which is something that is done in house – from here, the components are ordered; with the tubular chassis being assembled from offsite laser cut components, whilst the bodywork is produced by an offsite composites specialist.

Lawrence Tomlinson's direction has been to develop Ginetta from it's 'kit car' roots; a large number of the components on the car are now custom Ginetta components – as many Ginetta owners use their cars in demanding motorsport applications, this provides a revenue stream as and when components are broken on the track. Additionally, because of it's small size, Ginetta can manage the **CUSTOMER RELATIONSHIP** in a much more personalised manner.

Whilst Ginetta's products are motorsport focused, the firm has taken an interest in the potential gains of bringing a ULEV to the marketplace and has developed the G50EV.



**Figure 102 - Ginetta G50EV Electric Sports Car Prototype Being Maintained**



**Figure 103 – Ginetta F400 (IP acquired from Farbio)**

The development of the G50EV vehicle has provided Ginetta with a wealth of experience, which has been useful in helping the company make decisions in respect to entering the electric vehicle



marketplace. As a design exercise, the firm has gained much in the way of tacit knowledge in the way of exploring how to achieve ultimate performance from an electric vehicle; however, at the moment, the barrier to further development is the £98,000 price of the battery technology employed in the vehicle.

However, whilst not a production vehicle, the G50EV has been useful in garnering Ginetta a wealth of media attention, being the first production vehicle to be driven through the Channel Tunnel by John Surtees, (Williams, 2009)

The company has also acquired the rights to the design of the Farbio GTS, developed by Arash Farboud; Ginetta has set up production of the vehicle at the existing plant in Bath, and is selling the vehicle as the Ginetta F400. The vehicle marks a departure from Ginetta's current offering, as with carbon fibre body panels and 'road car' styling, Ginetta has established a sub-brand, "Ginetta Supercars" in order to market the vehicle.

Ultimately, whilst understanding and knowing the **CUSTOMER SEGMENTS** that Ginetta serves have been key to the success of its motorsport business; it has also presented challenges. Ginetta applied for £1.7million government funding to develop the G50 EV further; however, according to an article published in (Autocar, 2010) the funding bid was rejected, as the vehicle was considered 'too niche'.

***"We could easily turn this into a usable everyday vehicle, not just a sports car prototype. We can extend the range to 250 miles - I drive it and charge it up using my windmill, so I don't see how the car could be any greener."***

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Lawrence Tomlinson, CEO Ginetta, speaking in (Autocar, 2010)

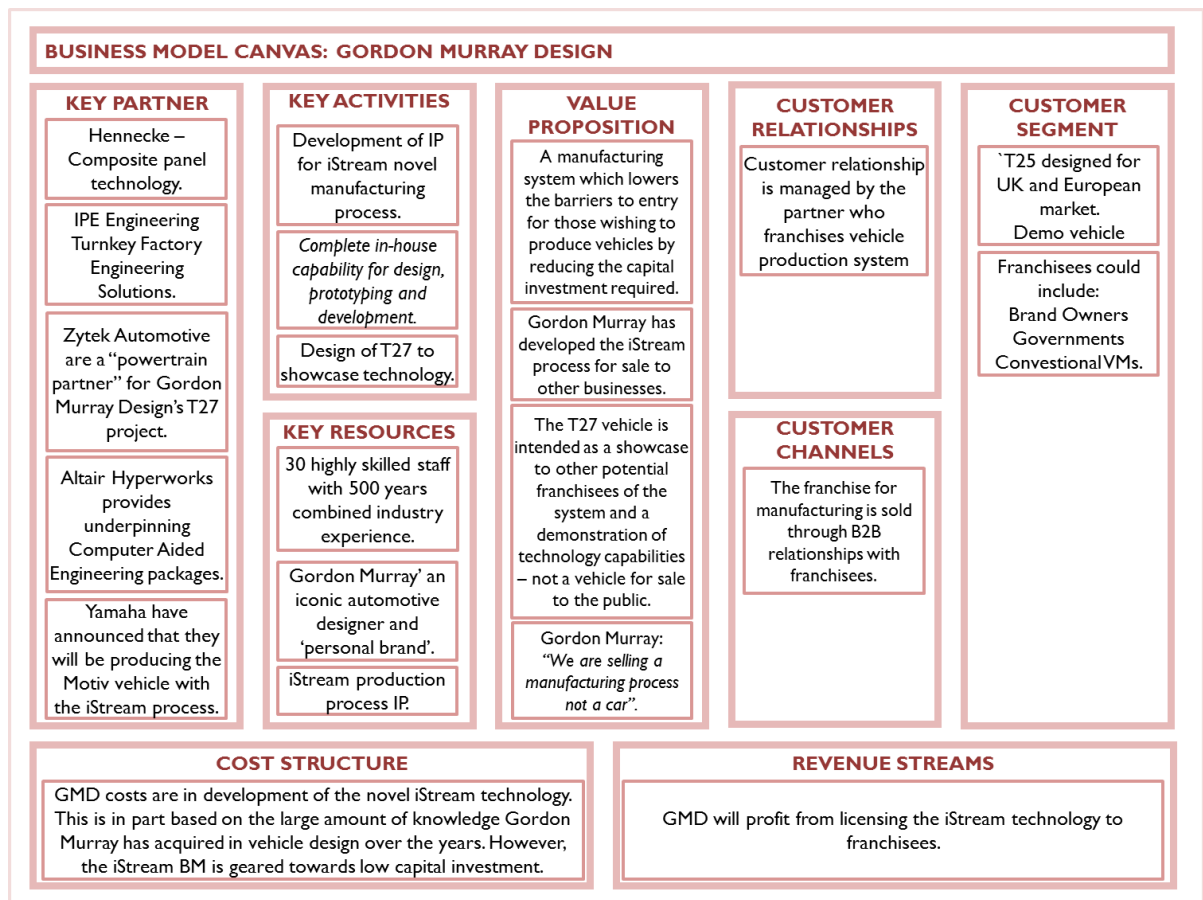
***"We're as busy as we've ever been," he said. "Order books are full on all our models for the next three months, so I'm not going to divert resources away from our core business unnecessarily."***

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Lawrence Tomlinson, CEO Ginetta, speaking in (Autocar, 2010)

Ginetta also has a petrol-electric hybrid LMPI in development in collaboration with ZYTEK Engineering, however challenging funding conditions (Autocar, 2010) have also put this project on hold.

## 7.8 Embedded Case Study: Gordon Murray Design

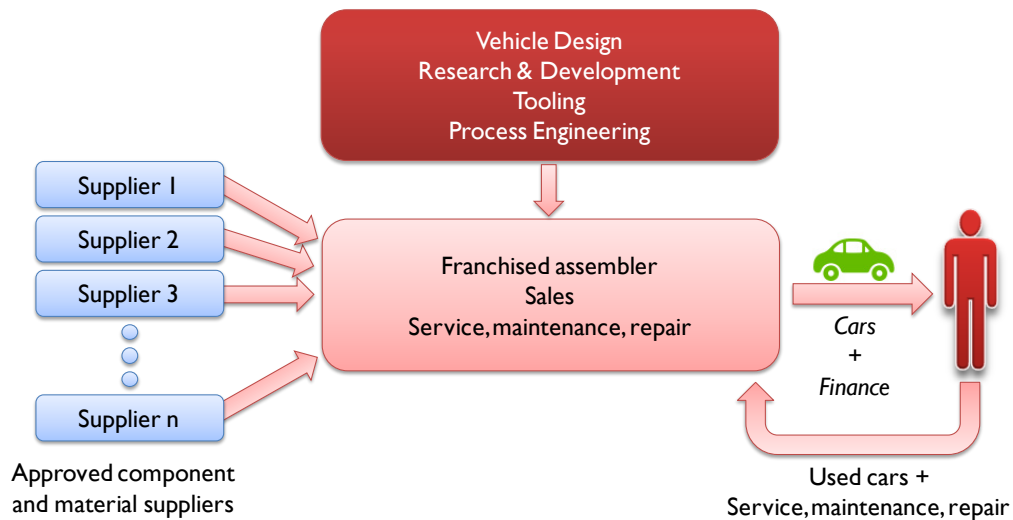


Business Model Canvas 18 - Gordon Murray Design Business Model

One of the first things that strikes you about the Gordon Murray Designs Business Model Canvas, is that this is a business model that is designed to reshape the way that vehicles are produced. The bulk of the information that is available about Gordon Murray Design’s novel “iStream” technology, relates to the processes novel approach to producing vehicles and the partnership Gordon Murray has forged to deliver this novel technology.

Whilst Gordon Murray himself has been responsible for some iconic car designs, such as the McLaren F1, the product that Gordon Murray Design itself is selling, is not a vehicle as such, but an “*innovative and disruptive automotive manufacturing technology trademarked iStream®*” (Gordon Murray Design, 2010). In an interview with Gordon Murray uncovers 'We’re selling a manufacturing system, not a car [...] T25 is just one example of what you can build using iStream.' (Procter, 2009).

Wells (2010b, p.122) presents the following diagram to represent the Gordon Murray Design Business model's interaction with its **KEY PARTNERS**.



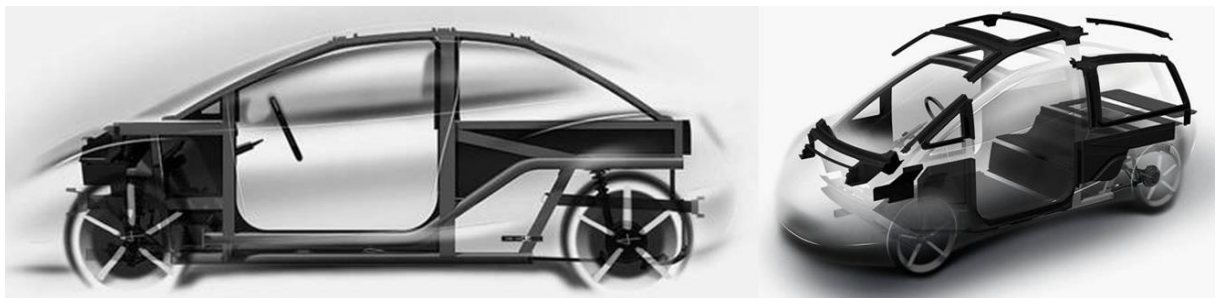
**Figure 104 - The Gordon Murray Design Business Model as viewed by (Wells P. E., 2010b, p. 122)**

*“Gordon Murray have billed the iStream® process as ‘the biggest revolution in manufacture since the Model T’ (Gordon Murray Design, 2010). “Some of the key changes from the conventional industry approach are in the way that the processes are configured.” Holger Erker, MD of IPE Engineering said: “From our analysis the iStream® process can be positively qualified as the most promising manufacturing process development in the car industry of the next decade” (Gordon Murray Design, 2010)*

As the product is the iStream® process rather than the vehicle itself, Gordon Murray views potential customers to include (Procter, 2009) ‘conventional car maker to governments’ later in the same interview, he also advances that ‘brand owners’ such as Apple, Virgin or Sony could leverage their brands . Interestingly out of 20 enquiries from 15 different countries (Procter, 2009) only seven were from existing vehicle manufacturers.

Kanellos (2009) describes Gordon Murray Design as an “IP Business Model”. Kanellos (2009) cites one of the shortcomings of the IP business model, is that the knowledge can often be copied. Furthermore, companies selling physical product can generate more revenue from a single sale. He highlights that the risks inherent in manufacturing physical product can be addressed through manufacturing outsourcing. ” South East Business Innovation & Growth (n.d) describe the process of putting in place protection for the iStream® intellectual property. This highlights another of the risks for the owners of an IP business model (Kanellos, 2009) – the need to engage in costly litigation to defend intellectual property rights. South East(South East Business Innovation & Growth, n.d) suggests that Gordon Murray Design have required support and assistance in developing an approach for protecting their intellectual property. Since IP would seem central to the GMD business model,

### 7.8.1 iStream Process



**Figure I05 - Exploded View of Vehicle Produced With the iStream Process**

The iStream process is a radically different process for the production of vehicles, that dispenses with the use of steel pressings as used in conventional vehicle design. Instead, the vehicle is build from a tubular steel frame, then ‘sandwich’ composites are used for structural elements, firewalls e.t.c; with impact-resistant plastic panels forming the vehicle exterior.

### 7.8.2 Gordon Murray T25

The Gordon Murray T25 was the first vehicle to be developed as a demonstration platform for Gordon Murray’s design for the iStream technology. This point is reinforced in a Gordon Murray Design (2010) press release which states; “the design and prototyping of the T.25 city car was central to both the development and validation of iStream®”. As the first vehicle to be developed to demonstrate the technology, it is

perhaps unsurprising that it is based upon conventional internal combustion engine technology. Given that the engineering process for producing the vehicle bodywork itself is already novel, the rationale of first working with simple proven technologies is uncontroversial, and a similar approach was adopted by Axon Automotive (see page 307) who at first worked with simple ICE technology. Whilst in practical terms the petrol drive-train produces emissions, the fact that this vehicle is significantly smaller and lighter means that the vehicle's emissions are drastically reduced. The T.25 prototype is estimated to have 40% of the lifecycle emissions of a Mini in use (Owen, 2009) [It is unclear whether this refers to the original Mini or later BMW redesign]. Here, in making a vehicle with reduced environmental impact, the focus was on downsizing of the vehicle, rather than radical drivetrain innovation. Gordon Murray makes this point in an interview: *“the largest step forward in the next twenty years is to change driving behaviour and promote a cultural shift to smaller and lighter cars.”* (Owen, 2009)

That is not to say that the iStream technology can only be used to produce small vehicles. The iStream® technology is flexible enough to produce vehicles up to minibus size (Owen, 2009).

### 7.8.3 Gordon Murray Design T27



**Figure 106 - The Gordon Murray Design T.27 Concept Vehicle produced using the iStream process pictured at CENEX LCV 2013.**

The T27 was the next iteration in demonstration vehicles of the iStream technology. ZYTEK were a key partner in developing an electric drivetrain, to showcase that EV's could be built using the technology platform. The T27 project was funded as a strategic collaboration to the tune of £4.5 million, by the Technology Strategy Board (2009). ZYTEK commented that because of the tubular design of the iStream process, there were advantages for packaging the components of the electric drivetrain to make optimal use of the space available (Green Car Congress, 2011). In an interview with Gordon Murray, (Owen, 2009) touches upon this key point "Vehicle electrification is not as straight forward as the installation of an electric drivetrain in a car that is designed for a combustion engine. [...] At the moment electric powertrains are being used without the adequate consideration of vehicle design"

#### **7.8.4 Yamaha motiv.e**

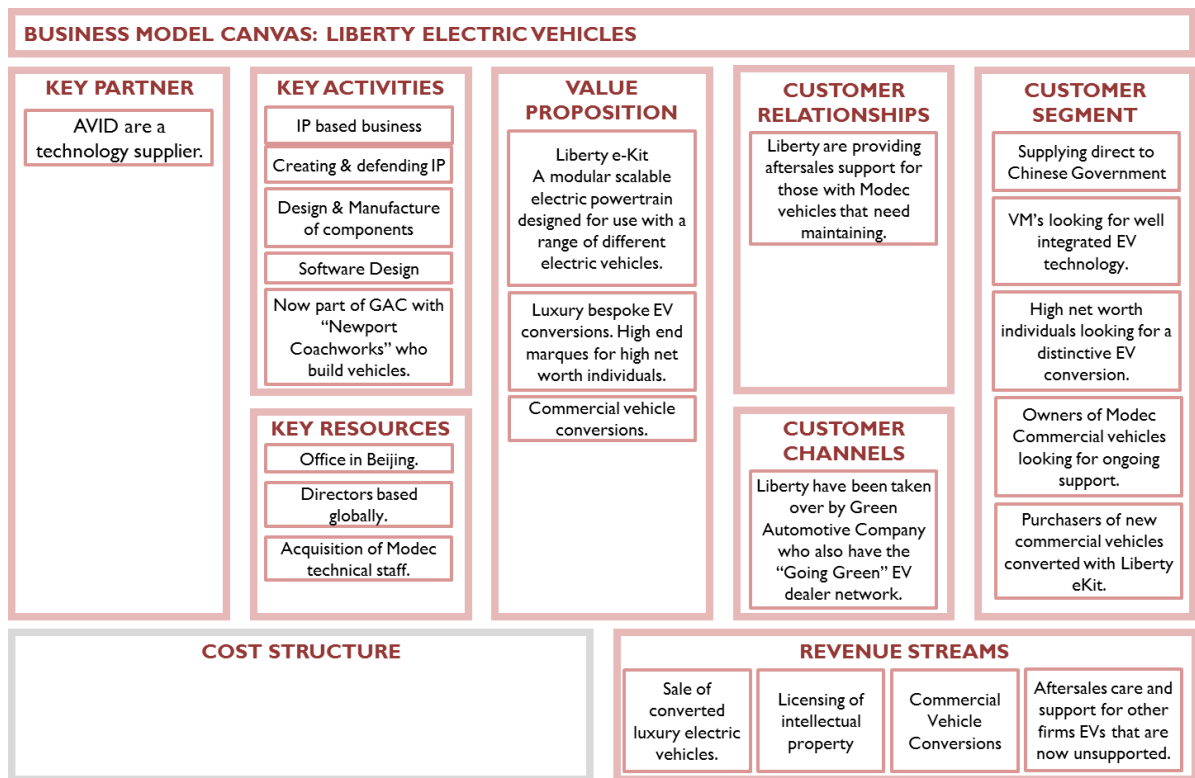
In the first partnership announced between Gordon Murray Design and a franchisee, Yamaha and GMD announced their intention to partner to produce the "MOTIV.e" city vehicle, at the 43rd Tokyo Motor Show (Gordon Murray Design, 2013). Compared to the T27 prototype, which by comparison is quite functional and utilitarian, "*the MOTIV.e is both a more complete vehicle and far more attractive as an urban runabout.*" (Miersma, 2013).

Yamaha has an established reputation for manufacturing vehicles, however, at present, the brand it more commonly associated with mopeds, motorbikes and trikes. Prince (2014) notes that this is not Yamaha's first four wheeled vehicle; the Toyota 2000GT was contract manufactured by Yamaha (Yoshikawa, 2002) a car that changed the world's perception of Japanese vehicles; furthermore, Yamaha have previously been engaged in contract manufacture of other vehicles (Mc Aleer, 2013).

The 8.8-kWh battery pack should give the EV a range of more than 100 miles "real world" and a three-hour recharging time from a "domestic socket" (with a one-hour quick-charge). (Miersma, 2013)

Kew (2013) notes that there are still uncertainties about the cost structure of the new business model compared to traditional car manufacturing. If the venture goes ahead, it is believed that the MOTIV.e will be priced at around £10,000 to compete with the Smart ForTwo and Renault's Twingo.

## 7.9 Embedded Case Study: Liberty Electric Vehicles



**Business Model Canvas 19 – Liberty Electric Vehicles Business Model**

When the research on Liberty Electric Vehicles was conducted, their business model was based around IP and Orcestration. More recently, they have become part of the “Green Automotive Company”, which brings Liberty together with “Going Green” a customer facing dealer network, and “Newport Coachworks” a US company with manufacturing capabilities, the combined business models of this range of companies therefore, is even more compelling.

The role of Liberty Electric Vehicles, shares some aspects of the ‘orchestrator’ business model, which has been discussed outside the automotive domain, in relation to the (Ordanini, Kraemer, & Dedrick, 2006, p. 3) who cite (Dhanaraj & Parkhe, 2006) describing the orchestrator as “*a management literature metaphor to describe the role of a player which organizes and manages a set of activities in a network, by ensuring value-creation opportunities in the system and value appropriation mechanisms for each player*” Liberty Electric Vehicles are exploiting an ‘intermediate’ position in the value chain, between ‘production’ and ‘distribution’ (Ordanini, Kraemer, & Dedrick, 2006, p. 4).



Another parallel between the business model of Liberty Electric Vehicles and Medion, is how this business model allowed for 'flexibility' which allowed the company to stay dynamic, and respond to a changing *regime* in the personal computer marketplace. Citing, (Hacki & Lighton, 2001) in their description of Medion as an 'orchestrator', (Ordanini, Kraemer, & Dedrick, 2006) explain – in terms that could equally apply to Liberty Electric Vehicles that this business model entails “fewer assets, and by leveraging resources of partner companies, it can be better protected against market volatility”.

Barry Shrier is clear to see where niche companies can really add value to ULEVs – by developing the core competencies, and technologies that the mainstream industry is neglecting, whilst letting the industry work on the things that it is good at:

***I know someone who is trying to launch a new car completely from scratch. He said that we're really struggling to get the doors to fit the body. That was so stupid. I believe the automotive industry solved this problem about 100 years ago. Why are you doing that?***

---

**Barry Shrier, CEO Liberty Electric Vehicles**

Perhaps some of the most interesting developments to the Liberty Electric Vehicles have taken place since the primary research was conducted. At the time, the Business Model Strengths were based around a core of innovative IP. However, in what could be termed “niche agglomeration”, Liberty have acquired the engineering expertise from Modec when they passed into administration.

### ***Acquisition of Modec Expertise***

Modec passing into administration is covered on page 348. The collapse of Modec led to Barry Shrier, CEO of Liberty Electric Vehicles “investing significant resources” (Loveday, 2011) into seeing whether Liberty could rescue Modec. In addition to the quote below, Shrier noted that a tie-up between the two could result in the emergence of a “formidable” player.

***"It's a sad day for the automotive industry as the UK has become the epicentre of electric vehicle technology – a position we must not relinquish. I believe Modec needs to be rescued by a UK firm to secure jobs and retain engineering expertise in this country."***

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**Barry Shrier, CEO Liberty Electric Vehicles,**

### ***Acquisition by Green Automotive Company***

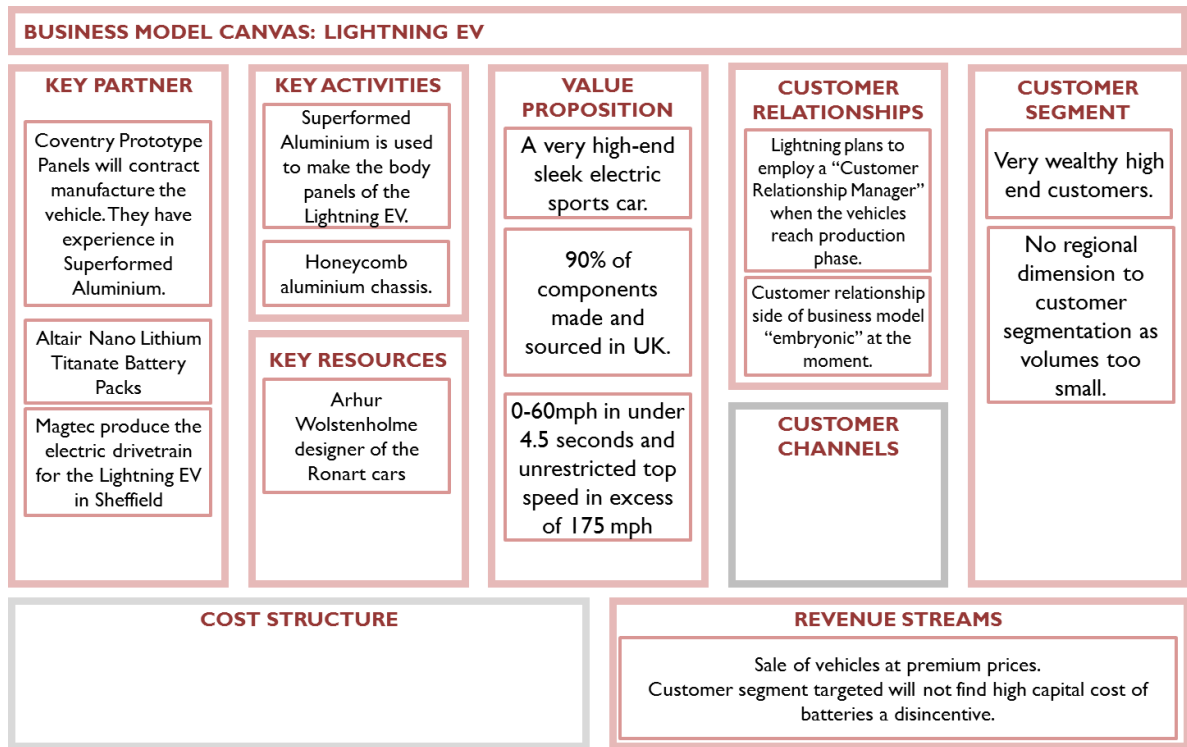
Liberty Electric Vehicles was in turn acquired by the Green Automotive Company. This brings together an American Firm, “Newport Coachworks who specialise in bus, minibus and commercial vehicle conversions, with Liberty Electric Vehicles and also “Going Green”. Going Green brought the G-Wiz quadricycle to the UK, which became in turn very successful. Going Green was also a dealership for electric vehicles. Taken in consideration with the acquisition of Modec above, it is interesting to see how the Green Automotive Company has begun to assemble brands that represent different stages of the value chain, from design, technical knowledge and IP, through manufacture and eventually a distribution network and aftersales support.

From a transitions perspective, this is particularly interesting- here are a collection of niche companies. All of which performed roles in different parts of the electric vehicle value chain.

Going Green built it’s reputation in the early days of the electric vehicle industry by distributing imported electric quadricycles in the London market that was hungry for them. To some degree, as volume manufacturers have started introducing more credible ULEVs to the marketplace, demand for these has declined.

Newport coachworks adds manufacturing capabilities, whilst Liberty provides a wealth of Intellectual Property. Already, these small companies coming together create potential for an interesting electric vehicle enterprise that looks set to grow in size and capability.

## 7.10 Embedded Case Study: Lightning



Business Model Canvas 20 - Lightning Business Model

The Lightning Electric Vehicle is a performance EV with exceptional styling developed by a small team.

***My thinking was in order to get electric vehicles into the consumer conscience. The only car at the time was the G-Wiz. What was needed was a car which had grace, performance, style and be very upmarket – in order to get opinion leaders out of their petrol cars and into electric cars.***

Design and styling are all done in house; Drive in Ripley helped with the final iterations. The organisation is small and lean currently employing five people. The firm has been kept small by outsourcing production to a contract manufacturer. The maximum volume with 250 cars a year; made in Coventry. The vehicle will be produced by a high end sports car producer – Coventry Prototype Panels.

***In order to create an aspirational car, you have to give them what they want. So to attract the high end purchaser, you have to create something timeless. Our design is timeless. People want performance looks and style – the electric car industry has spawned a number of hideous designs and dreadful brands.***

Considering the Customer Segments that Lightning are targeting, Sanderson answer with an example:

***Say a hedge fund manager working in Mayfair; he uses his DB9 V12 in heavy traffic in London; but he wants to look good and feel good –that’s why I bought a DB9. You have to look at that market place and say “right, these people are discerning, they want a classy car that makes a statement about themselves. And If you can give them a vehicle that is zero emissions at the point of use, that makes them feel even better about themselves.***

---

The car is made in superformed aluminium, a process which works at smaller scale. (Superform, 2014)

The vehicle has a traditional construction with a separate chassis.

***The technology has led the business model – you have to produce a car that delivers; if you want to deliver range you have to have enough batteries, if you want to have performance you have to deliver the right powertrain,. If you want to have good bodywork, you have to have upmarket top class styling and bodywork. This car unlike other cars which have been based on other companies platforms [...] this is machined that this car has been built as an electric car; bespoke design rather than taking something off-the-shelf.***

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Supply chain components are sourced from a variety of manufacturers; this presents some challenges due to the smaller scale of production – as a SME market manufacturer, Lightning do not have the purchasing power of a large OEM.

***Finance determines whether to develop components in house, or whether to buy products that are developed externally. In a fast moving industry, you want to ‘be fleet of foot’, you have to make commitments, but also you don’t want to be outmanoeuvred by new technology – you want to take a look at it. By contrast, a large manufacturer has to commit to large volume for the long-term; huge volumes. In a new marketplace, that is very dangerous.***

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Characterising the firm’s Key Partners, Lightning are working together with Altair Nano, a lithium titanate supplier – their batteries have a wider operating band of temperatures; and their discharge, they can run down to zero percent. Furthermore, another thing that made this technology appeal cycle range is much higher; we can have more cycles than any other car on the marketplace – the batteries are expensive, but then our car is designed to be the best.

Referring to the most important costs in the business model; battery and powertrain comprised the largest costs; the labour costs have been reduced through keeping the business lean and agile; and using a small core of very capable people. Also, raising the capital from 'within' to start the business, the business is free from the constraints of having to satisfy external shareholders, or meet the short-term expectations of venture capital funders.

*"We want to get cars into production, and on the road. We are ambitious to get our car out there, on the road and doing it's stuff"* when questioning moves to discuss whether there is an 'exit strategy' for the business, Sanderson maintains that Lightning want to maintain their independence as a small, luxury manufacturer.

At the moment plans for the distribution network and **CUSTOMER RELATIONSHIP** management are embryonic –however, given the small number of customers, Lightning can form a very strong personal bond with the customer, as part of the consumption of the luxury purchasing experience. Lightning will be employing a **CUSTOMER RELATIONSHIP** manager, whose sole job will be to ensure Lightning's customers remain happy. There isn't a regional dimension to Lightning's marketing strategy – due to the low volumes.

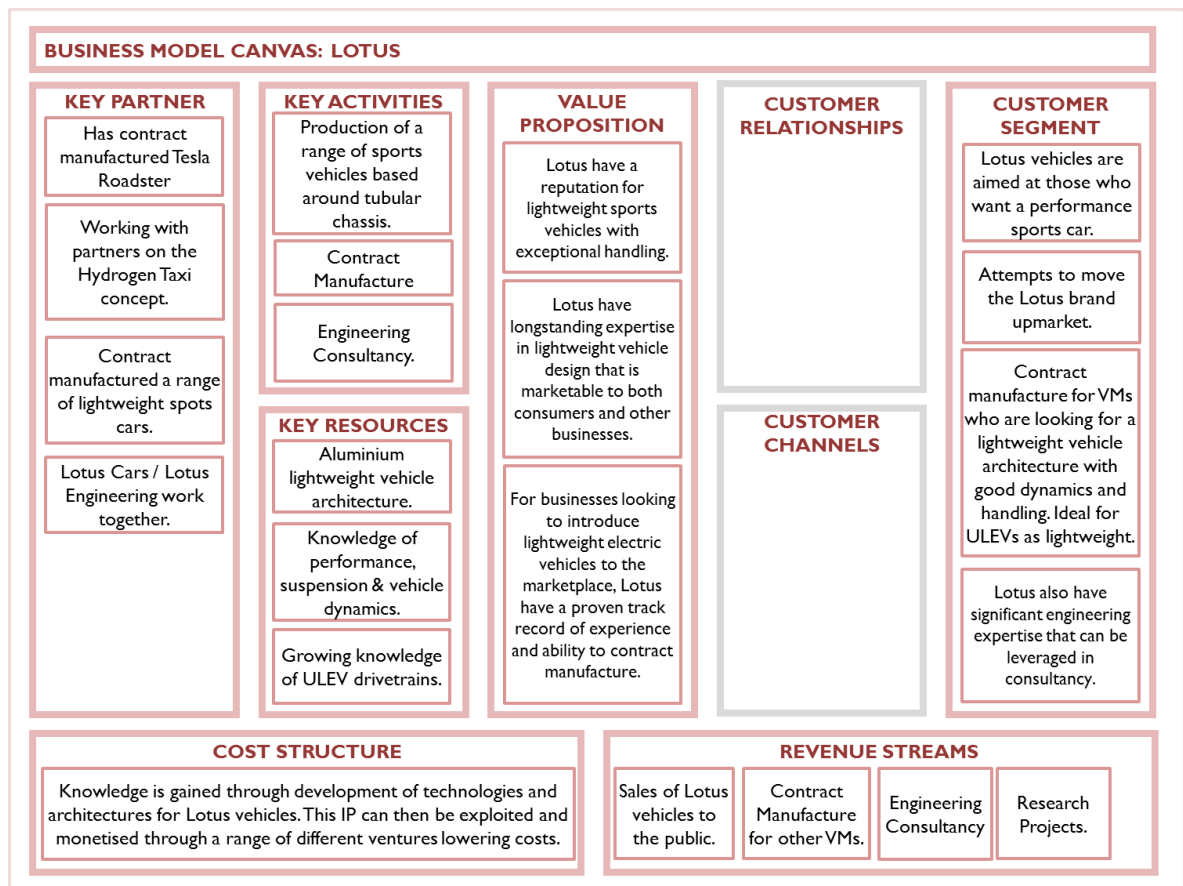
Sanderson feels strongly that Lightning are selling into the existing high-end luxury sports car market, rather than creating a new market for the product; Sanderson clarifies

***"we do not see this as a "green" sports car', we see it as a sports car that the conventional sports car driver can drive and get a lot of satisfaction out of; with the added bonus that it is zero emissions at the point of use. We are not targeting eco-warriors at all; we are talking about giving people the chance to have the drive they have always enjoyed – the looks and performance of a very fat car, but without the emissions – you won't get the V8 rumble, but it will be very smooth, no emissions and when you see it in the flesh it is a stunning car."***

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One of the inherently sustainable features of luxury cars that has been identified by Sanderson in relation to the Lightning car, but not perhaps recognised, is that "it is designed to last for years and years". This has also been discussed in the literature by (Wells P. , 2003)

## 7.11 Embedded Case Study: Lotus



**Business Model Canvas 21 - Lotus Business Model**

Lotus have tried to reposition their brand, moving it “upmarket” into supercar territory. In line with this transformation, Lotus has said it will reduce its number of UK dealerships from 23 to 3 and it’s number of international dealerships from 160 to 135. (Saward & Arnott, 2010).

The Lotus’ business model is potentially very interesting because of its multi-faceted nature. This is reflected in the structure of the business – and it is through the development of it’s unique sports vehicles that it has gained knowledge in lightweight vehicle technologies.

***Lotus is an unusual company, in that there are two businesses that operate under the heading Lotus – Lotus Cars Ltd. Which manufactures Lotus own sports cars, and where there is commonality of chassis components, is prepared to make cars for other people. Previously this has included vehicles such as the Vauxhall VX220. Currently, this includes work for Tesla. The other side of the business is Lotus Engineering Ltd, which is a company of approximately the same physical size in terms of***

*numbers of people spread around 3 sites around the world. Lotus Engineering provides engineering contract services, to typically larger automotive companies.*

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Simon Ward, Lotus

### 7.11.1 Lotus Aluminium Architectures

Lotus have been able to leverage their knowledge of lightweight aluminium vehicle architectures, through a range of contract manufacture deals with different vehicle manufacturers. From the perspective of ULEVs, the technology is interesting because of its lightweight. Lotus' proven experience with lightweight structures gives them early advantage in the race to bring electric vehicles to market.

Manufacturer	Model	Lotus Model Based On
Dodge	EV	Europa
Tesla	Roadster	Elise
Tesla	X SUV	APX Concept (?)
Vauxhall / Opel	VX220	
ZAP	ZAP-X	APX Concept

Table 22 - ULEVs in development based on Lotus VVA

Compiled from information in (Abuelsamid, 2009; Abuelsamid, 2008; Michalik, 2011; Green Car Congress, 2007)

Based on the qualities of high rigidity, whilst being very lightweight, the unique characteristics of Lotus' VVA has led industry commentators (Zart, 2009) to question whether Lotus is the next big electric vehicle platform developer. The strength of the vehicle platform lends itself to supporting heavy batteries EV designs necessitate; whilst the lightweight body structure contributes to vehicle efficiency.

**Steve Swift, Head of Vehicle Engineering,** "We expect that the demonstration of this technology through a real understructure will stimulate yet more interest from OEMs or consortiums looking to produce exciting products utilising cost efficient, proven architecture," (**Lotus Cars, 2005**)

Traditionally OEMs seeking to gain competitive advantage through exciting niche vehicles have to either design a new platform or share one already available. Engineering a bespoke low-volume

platform is an expensive, time-consuming solution, whilst sharing a mainstream chassis normally results in compromises in performance and design.

***Lotus Versatile Vehicle Architecture (VVA) has been developed to bridge a gap in the investment-volume curve to exploit the benefits of producing at medium volumes but for niche markets, thereby giving the best chance of business case success and favourable returns. VVA exploits Lotus Engineering's expertise in aluminium, steel and composite body engineering, joining techniques, and vehicle systems integration. This innovative technology offers a fast-to-market, cost-effective approach to differentiated niche products by spreading the development, investment and bill of materials burden across a range of niche vehicle variants, without the compromise that stems from conventional 'platform sharing'***

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Lotus Cars (2005)

### **7.11.2 Hydrogen Taxi**

Lotus will also be involved in building a number of hydrogen fuelled taxis for the London Olympics in 2012 (Saward & Arnott, 2010), a Technology Strategy Board funded venture. Here, Simon Wood was quick to highlight that if the TSB were not funding programmes, it is unlikely that Lotus would be undertaking the level of research and development that was presently taking place. Here they saw such programmes as adding a vital incentive, to do more research than they would otherwise do – and also provided a useful forum for discussion with other consortium members. Here, it is interesting to note how this funding stream has helped develop new networks of ‘Key Partners’ for future commercial opportunities.

***To apply for funding, you need to have a number of other companies working with you, so it forces you to go out and find other companies that are experts in their own field to work together – and that then of course leads on to other commercial opportunities.***

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Interview with Simon Wood, Lotus

The bid to develop the Hydrogen Taxi was led by Loughborough based Intelligent Energy, who saw the taxi as an ‘arena’ within which hydrogen fuel cells could make a great deal of sense. Here, the potential ‘Value Proposition’ of a Hydrogen Fuel Cell solution in a taxi application is outlined.



*'Taxi's spend a lot of time stationary (waiting for a fare), they tend to cover short distances, at a relatively low speed. They are also a restrained fleet – you know roughly where they will be. Furthermore, they all go back to roughly the same places – outside stations, airports, e.t.c. looking at the needs, if the desire is for zero emissions at the point of use – for use in dense city environments, high efficiency – for CO<sub>2</sub> savings, also if you are looking for reduced noise and other pollutants then a fuel cell is a fairly sensible way to do it. If you did it with a straight battery system, you would have to have a very large battery pack, and you wouldn't get the range. Additionally this would impact other aspects of the design – the Public Carriage Requirements, which stipulate wheelchair access, boot space e.t.c.*

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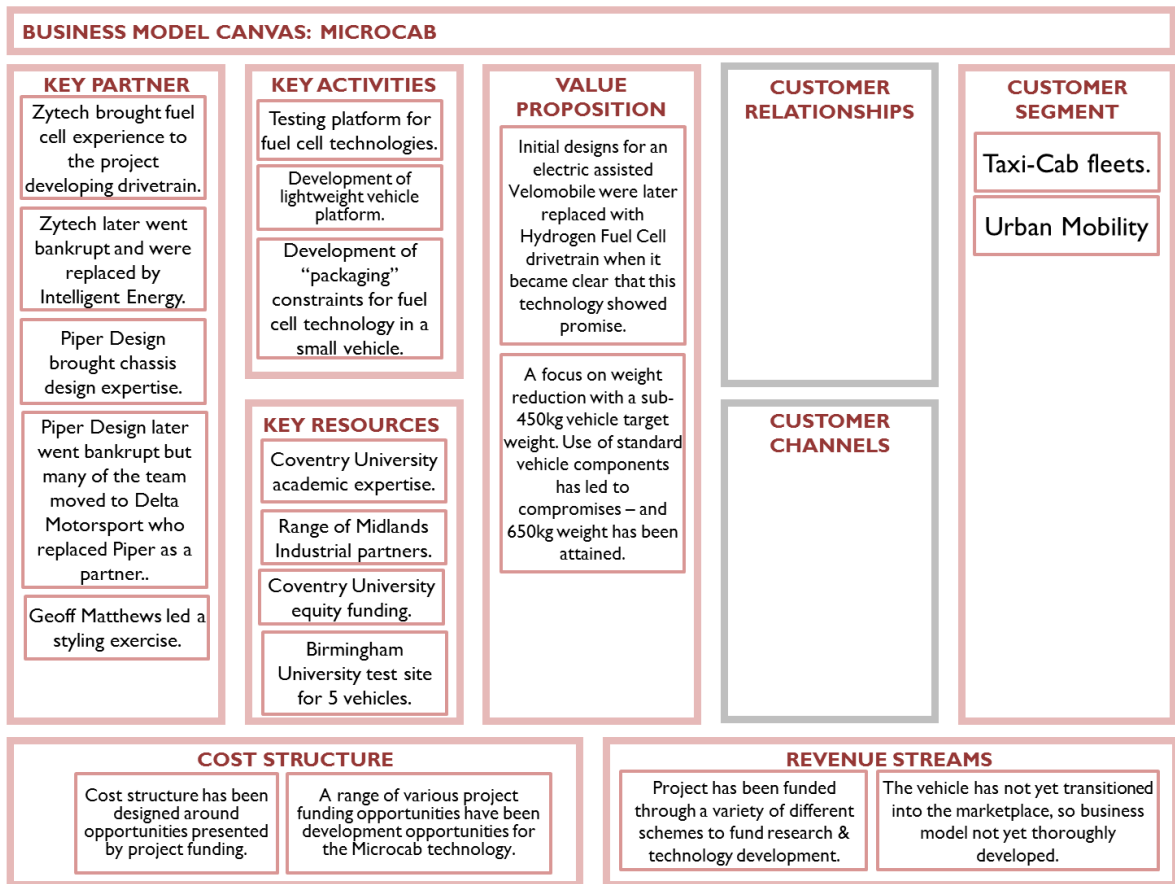
Simon Wood, Lotus

*From a Lotus perspective, what is interesting for us is that this could be a "real use" for fuel cells. Lotus desire is to offer engineering services – principally that is integrating electrical equipment, into a vehicle or changing the chassis dynamics, and the weight of the vehicle to make it more capable. So it brings together a number of things that Lotus want to be world class in. They are embodied in this case in the Taxi. [...] Lotus doesn't get a product out of it, but what we do get is a deep understanding and working knowledge of how to integrate components from other people into a taxi.*

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Interview with Simon Wood, Lotus

## 7.12 Embedded Case Study: Microcab



Business Model Canvas 22 – Microcab Business Mode Canvas

Microcab is a spin out from Coventry University’s expertise in vehicle design (Tovey, 2010). The goal of the project evolved quickly from making a generic, lightweight vehicle for urban environments, to assessing the feasibility of hydrogen and fuel cell technologies. The project has been funded through a number of different schemes and initiatives. Over time, the vehicle concept has evolved and gone through several iterations. One constant throughout the project has been Prof. John Jostins of Coventry University. Tovey (2010.) charts the progress of the Microcab concept since 1996; when hydrogen and fuel cell technologies were “*considerably further from the mainstream*”. The vehicle has been designed with the taxicab **CUSTOMER SEGMENT** in mind.

The initial project for was a part pedal powered, part electric drive cab vehicle. This was exhibited at the European Velomobile Exhibition (Tovey, 2010). However, early on in the project, it became clear that Hydrogen and Fuel Cells were emerging rapidly as a promising future technology for ULEVs.

Over a period of years the Microcab has gone through several design iterations; the design of the vehicle has been successively improved. The technical details of the present Microcab design are explored in Fisher, Jostins, Hilmansen & Kendall (2012).

The present vehicle is based around a steel frame, with a honeycomb aluminium floor and GRP body.

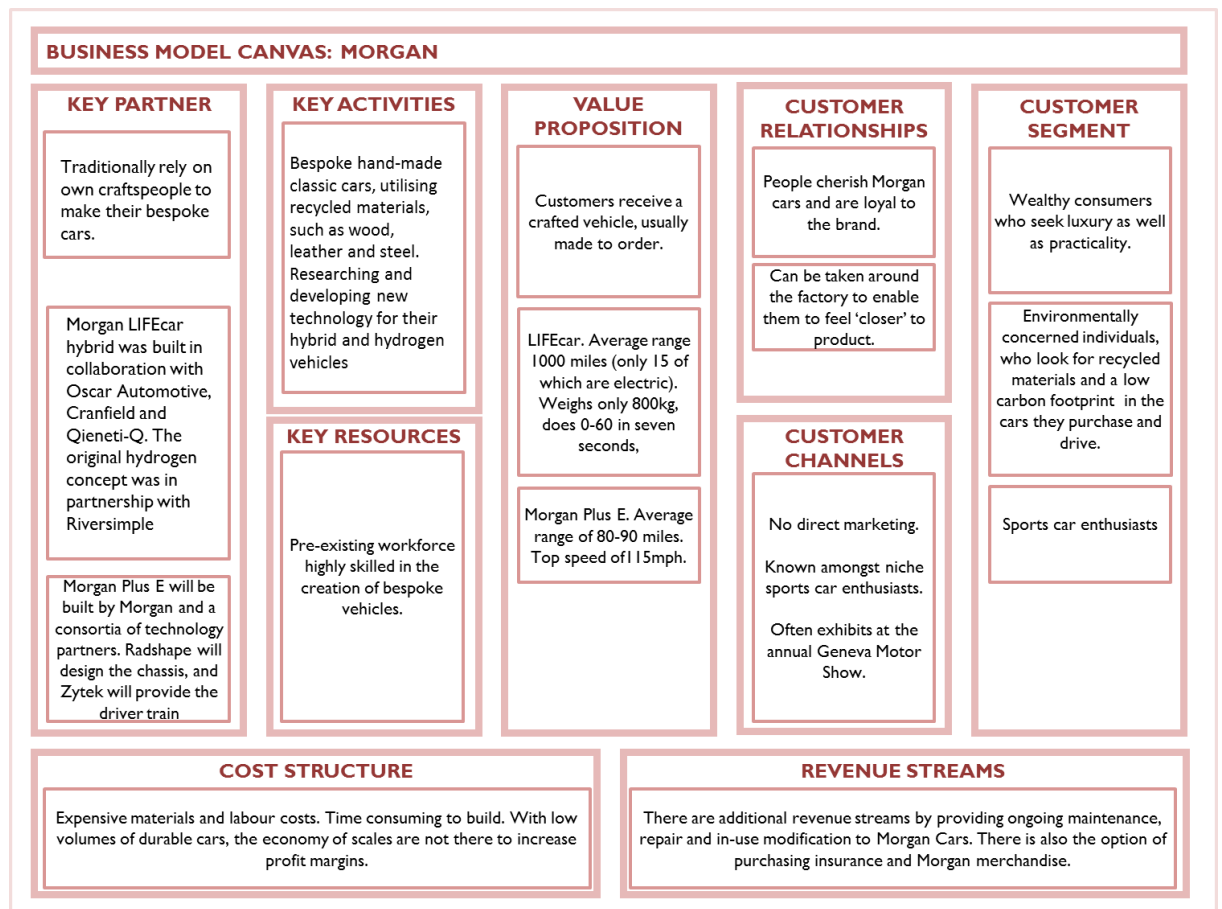
The fuel cell drivetrain has evolved with the vehicle's development. Initially, a Ballard Nexa Fuel Cell stack (1.2kWe) was used. This was a packaged fuel cell, complete with all of the balance of plant, designed for experimentation. However, this was found insufficient to power the vehicle and so later iterations employed a Serenergy (3.2 kWe) fuel cell.



**Figure 107 – Present Iteration of the Microcab Vehicle Design**

The Microcab vehicle has been designed with a clear customer segment in mind; however many elements of the business model are not clear at these small scales of production. At the moment, the Microcab is a product that is in need of a business model to bring it to the marketplace – however, through several iterations of projects, Microcab have been tenacious in proving and demonstrating a technology that some larger vehicle manufacturers have not.

## 7.13 Embedded Case Study: Morgan



Morgan, is a small car maker with a staff of 156 people (Squatriglia, 2008) / 170 (Morgan, 2011). The company is renowned for its hand built cars, distinctively styled with a 1930's aesthetic (Squatriglia, 2008). Morgan's vehicles are considered to be a "a prestige product for a global market" (Morgan, 2011). There is a long waiting list for its hand-built vehicles that integrate traditional coachbuilding methods with modern technologies.

Morgan has grown, slowly but steadily, famously ignoring the advice of TV's Troubleshooter Sir John Harvey Jones to expand rapidly, instead focusing on more gradual growth.

Year	Number of Cars
1990	400
2000	500
2011	1000

Table 23 - Morgan Motor Cars Growth in Production

A number of commentators noted the contrast between Morgan's apparent small firm size, and the achievement of developing a hydrogen fuel cell vehicle (Squatriglia, 2008).

There are similarities between the technical **VALUE PROPOSITION** offered by Morgan and Riversimple – with Charles Morgan quoted in (Bloomberg Business Week, 2007) as saying "*The paring of weight to a minimum is our strength and allows a much smaller fuel cell than conventionally though necessary. This gives energy and yet more weight savings.*"

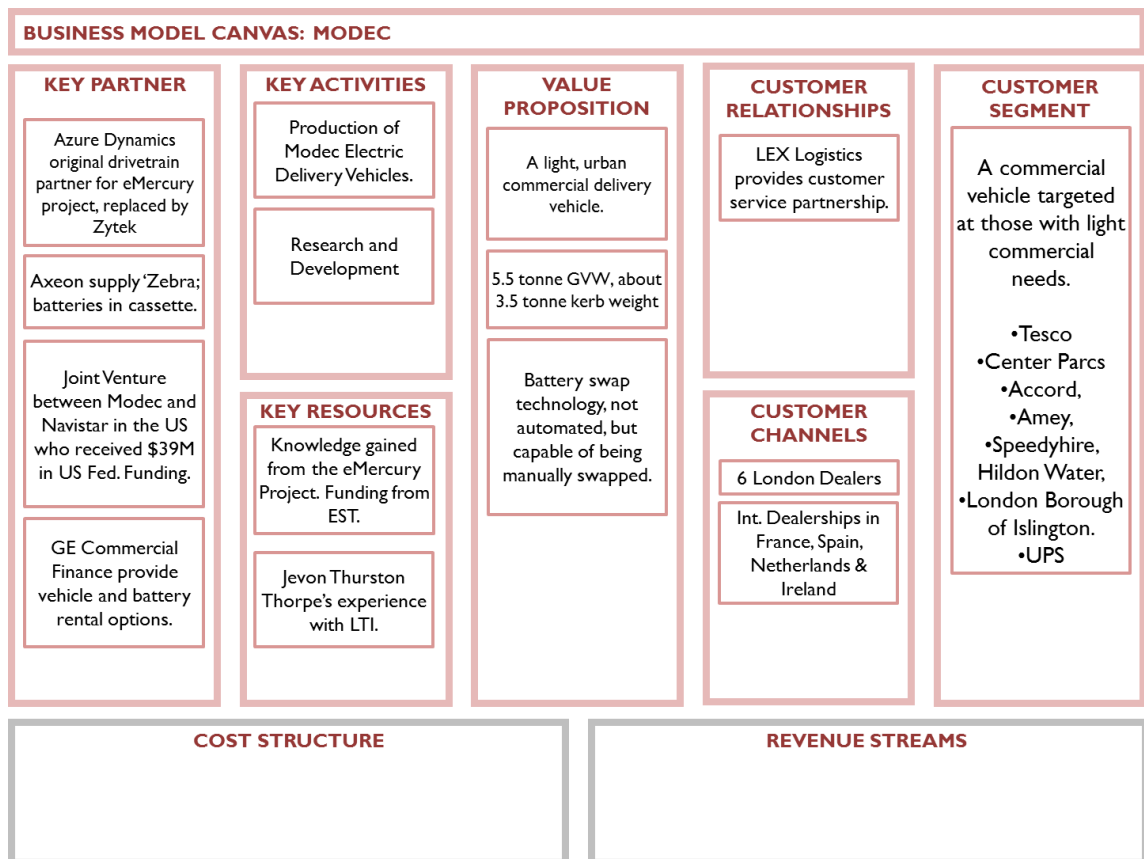
The Eva GT extends Morgan's traditional **VALUE PROPOSITION** by bringing to the marque the practicality of a 2+2 seating arrangement, giving greater flexibility and appealing to a greater range of **CUSTOMER SEGMENTS**. Furthermore, it builds on the previously discussed virtues of lightweight body construction and longevity resulting from its enduring appeal to consumers. There is an Morgan Eva GT (Morgan C. , 2011) "*an electric hybrid version [is in development with] Birmingham City University*"

Charles Morgan has said that the company will expand the number of **CUSTOMER SEGMENTS** which it aims to target, saying that it "*will target new niches.... electric sports cars, fun weekend cars **AND** cars for young families.*" Whilst marking the change of strategy with the note "*This is a considerable revolution for a company that is famous for making the same car for 50 years!*"

The novel 'sustainable' **VALUE PROPOSITION** offered by Morgan cars, is only made possible through the unique configuration of **KEY ACTIVITIES** (Morgan C. , 2011) the company is also trying to work towards faster development cycles 'from 2011, a new vehicle will appear every two years' (Morgan Motor Company, n.d.)

Morgan has employed a diverse range of **KEY PARTNERS**, for a small firm, it's lineage and heritage has counted in it's favour. Morgan has had collaborations in place with Ford Motor Company BMW Siemens & BOSCH (Morgan Motor Company). For the 'lifecar' consortium, the fuel cell was supplied by defence contractor QinetiQ, Oxford University developed a novel motor capable of regenerative braking whilst Cranfield University developed drivetrain control electronics.

## 7.14 Embedded Case Study: Modec



**Business Model Canvas 23 - Modec Business Model**

Jevon Thurston-Thorpe led the team which introduced the TXI, a modern revision of the London Taxi. The project grew out of a final year dissertation at Warwick University 'Nothing but safe, accessible, blue skies' – the board of LTI then decided to give Jevon £500,000 to develop a prototype concept. Through this project, he was rewarded by becoming Managing Director of LTI, Working in this role for a number of years, Jevon wanted to return to product development. Whilst studying business with the Warwick Manufacturing Group, he was tasked with finding new ideas for Managnesse Bronze innovations "my mandate was to move from one product one market (the black cab in London), to multi product, multi-markets"

***"My mission was to come up with ideas that would complement the business; but also to generate ideas that would potentially 'put the business out of business', if you think about it – that is what your competitors are trying to do – not saying that I was trying to put us out of business, but more a case of looking at what we might do next"***

Interview with Jevon Thurston-Thorpe

It is interesting considering this last quote against Govindarajan & Trimble's (2011) three box approach to business model innovation. What was retained in the new venture however, was the core expertise of urban mobility. "How could we look at delivering goods in cities? Because we deliver people in cities – that's what Black cabs do, but what about goods." Thurston-Thorpe elaborates. The initial thoughts led to development of working prototypes through the 'eMercury programme.

In terms of Key Partners, the programme originally used technology from assured Dynamics, but they were in Vancouver. Later moving to UK supplied technology from Zytec technology and an Axeon Lithium Ion battery pack. Quantity demands shaped the change of key suppliers.

***"The reason that we developed the Axeon pack is that Zebra were unable to supply in the quantities that we required, so we had to make the move to an alternative battery".***

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The value proposition of Modec is unencumbered by the preconceptions of an existing product, that is to say that it was designed from ground up as an electric vehicle. What that enabled Modec to do was package the vehicle in an optimum way. This led to innovations like Q-BEx, Quick battery Exchange. This did not provide the PBP functionality of being able to exchange the battery, like a fuelling station, but was intended that if customers ever experienced a problem with the battery or wanted to replace it with a different size battery it was very easy to do.

One of the things that shaped the Modec value proposition was a tool called QFD, quality function, deployment – originally used in the Japanese Boat building industry, it is used to define very challenging customer needs. The design team listed all of the requirements and how they would best deliver them – which led Modec to challenge convention with an unconventional product design.

The Modec vehicles were designed to be 5.5 tonne GVW, about 3.5 tonne kerb weight, the battery was about 8-900kg, with the battery removed from the chassis, the vehicle weight was around 2.5 tonne.

Above 3.5 tonne, the classification changes to a different class of vehicle which requires different licensing. For 3.5-7.5 tonne a Class II license is needed. The Modec vehicle sat in the middle of the

range at 5.5 tonne. Some had argued that taking the GVW up to 7.5 tonne and increasing the vehicle wheelbase slightly would have led to a value proposition more in line with customer requirements. The current vehicle weight was arrived at through the QFD process.

#### **7.14.1 Administration**

Unfortunately, on the day that the factory visit to Modec was organised, a call was received that it would not be possible. A few days later, the news broke that Modec had entered into administration.

***"The business has experienced severe cash flow difficulties in recent times. This, combined with the tough economic climate, has led to the need for administration."***

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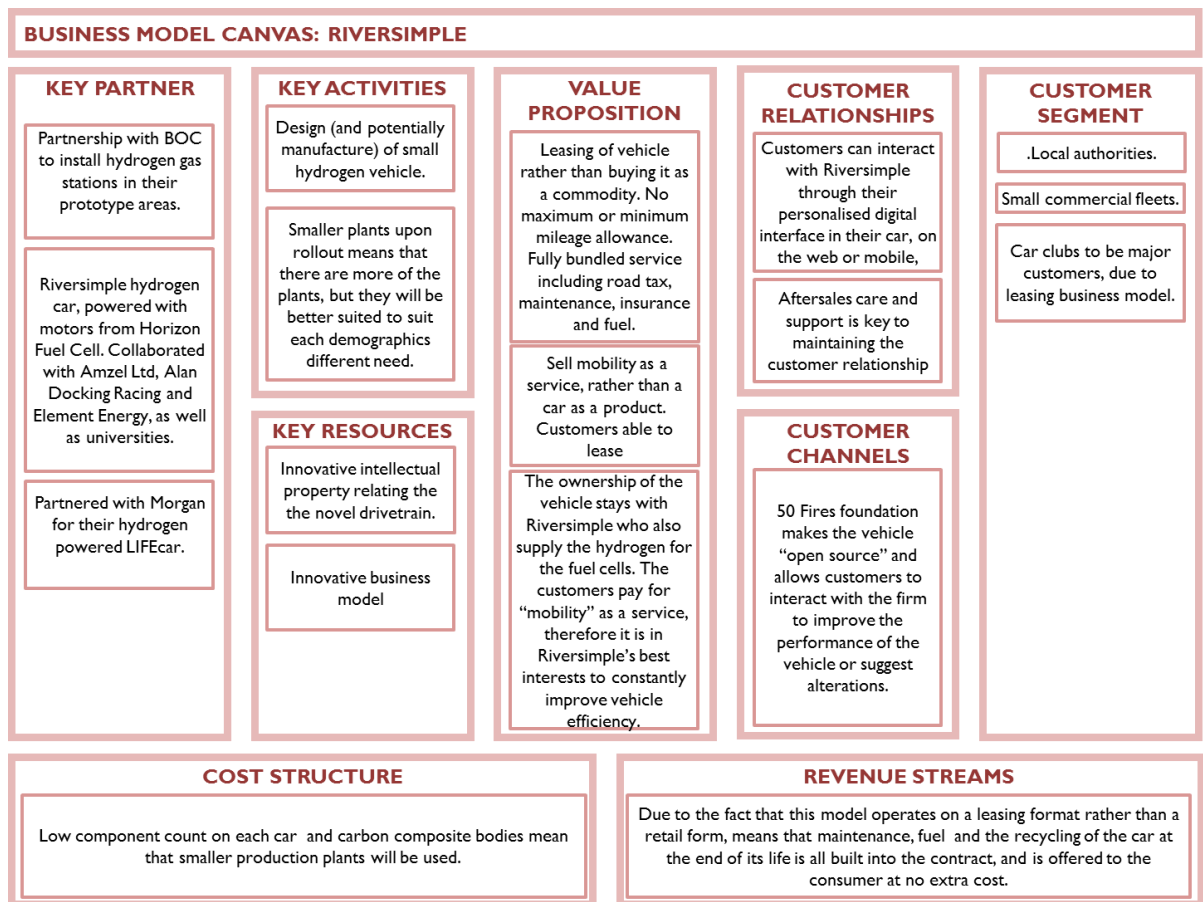
**Ryan Grant, Zolfo Cooper: quoted in (Walton, 2011)**

#### **7.14.2 Acquisition of capabilities Liberty Electric Cars**

After negotiations with Liberty Electric Vehicles, a number of the engineering staff and capabilities were taken on by Liberty Electric Vehicles.



## 7.15 Embedded Case Study: Riversimple



### Business Model Canvas 24 - Riversimple Business Model

Hugo Spowers Riversimple Business Model is radically challenging the conventional logic of the motor industry. In terms of the environment, the model exhibits many facets of what might be classed as an idealised 'sustainable personal mobility business model', however, in trying to challenge with such an ambitious business model, Spowers faces significant challenges in winning hearts and minds and challenging accepted wisdom. To begin with, there is the value proposition of a small 2 person vehicle. This is coupled with radically different key activities in manufacture, using carbon-fibre as a material of choice.

***“Some manufacturers that have investigated carbon fibre for vehicle bodywork, have tended to make comparisons with steel in terms of cost per kg – clearly this is madness, when carbon fibre, being stronger and lighter has that much more utility per kg”***

Hugo Spowers, CEO Riversimple

However, the innovations are not purely technical and product based, Spowers imagines a radically different configuration of the value capture dimension of the business model where customers pay for mobility as a service, rather than purchasing a vehicle. This ensures that the manufacturers have incentives to continuously improve the vehicle's efficiency.

***“The business model of the car industry has no inbuilt incentives for manufacturers to improve the fuel efficiency of the vehicles they are selling. At Riversimple, we are trying to change this, by ensuring that if we improve the fuel efficiency of the vehicle, the company benefits – and so there is an incentive to do so and our business priorities will therefore be aligned with the needs of the environment.”***

Hugo Spowers, CEO Riversimple

There is clearly a broad spectrum of opinion regarding the future shape, form and dynamic of the motor industry of the future, Spowers has said “We believe that the [motor]industry will look very different in the future” (Sunderland, Interview with Riversimple, 2009). Since this interview, there are hints that others are beginning to think the same way – whilst different in many ways, the BMWi business model based around carbon fibre, ULEV technologies and elements of service provision look nearer to Riversimple’s business model than the industry as it presently stands.

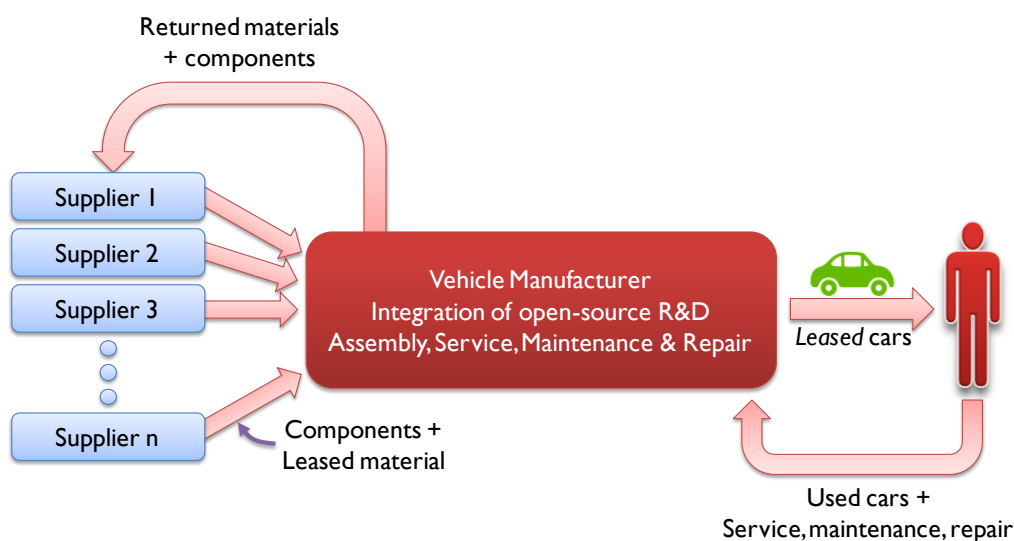
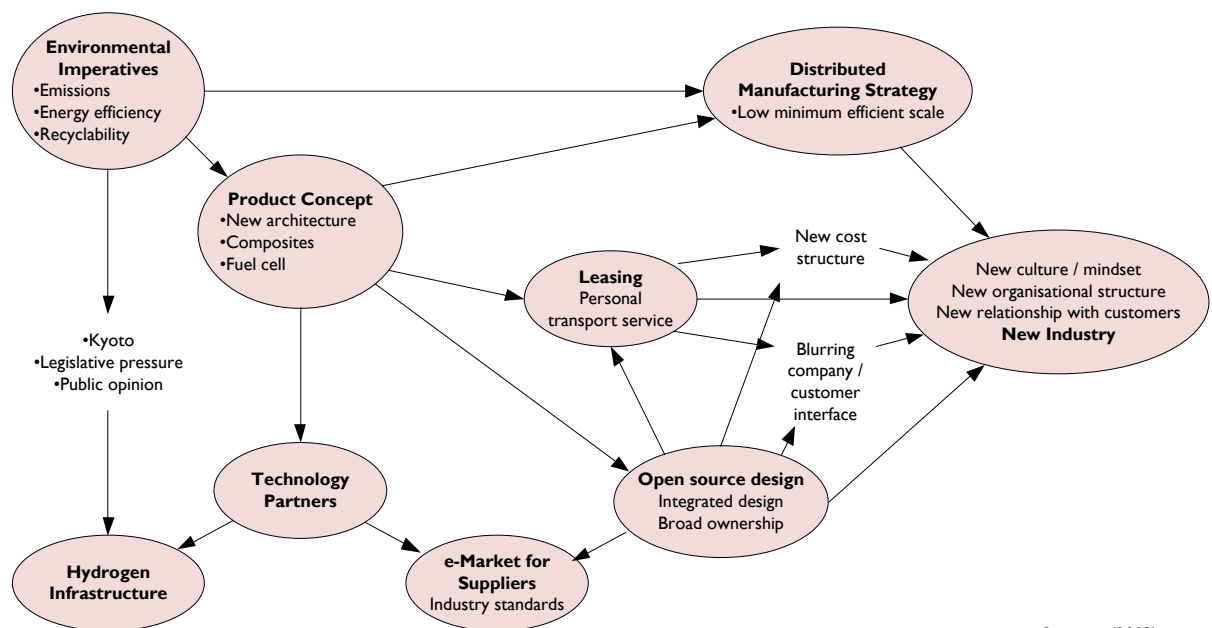


Figure I08 - The Riversimple Business Model as depicted by (Wells P. E., 2010b, pp. 125-7)

Spowers is keen to stress that the obstacles to a hydrogen economy are *perceived* rather than real; and innately tied up with the current industry conception of automobility. The conventional motor industry wisdom with hydrogen dictates that there are challenges in squeezing a greater volume of hydrogen into a smaller volume (and hence weight) tank. Large vehicles requiring large volumes of hydrogen by necessity have run into a number of technical challenges.

The 40 fires foundation has been established independently of Riversimple. The foundation is open to those with expertise in a range of fields that could potentially contribute to the Riversimple project.

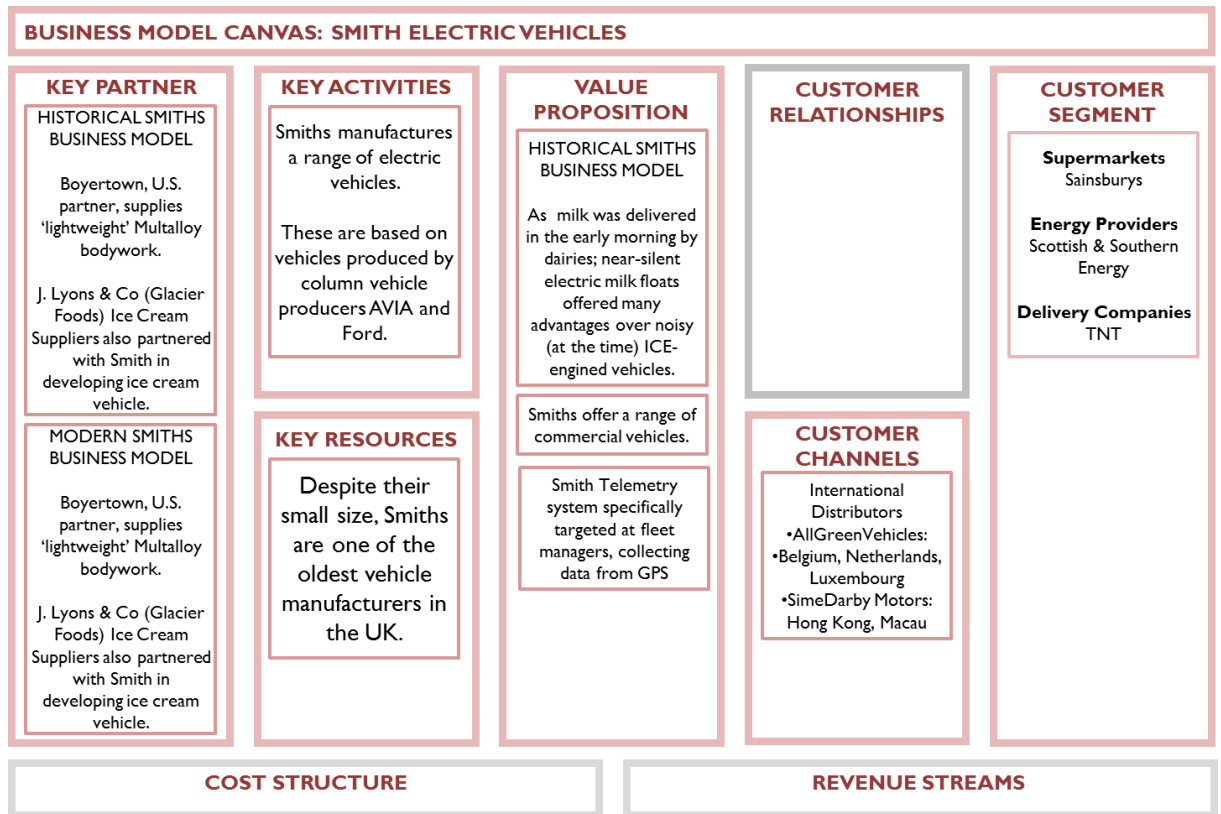
The car manufacturer (Riversimple) is responsible for all of the type approval and certification of the car. Riversimple will front this initial fee for type approval. If another partner wishes to license production of a car based on the Riversimple platform, then it will pay 60% of the development fees to Riversimple. In the event that another company wants to develop a vehicle based on the same platform, it will pay 60% of 60% of the cost of development. This is to ensure that the originator of the idea receives just reward for the development of the product; whilst not encouraging unsustainable and unequitable models of growth where all of the money generated from a design is "funnelled to the top".



Spowers (2002)

Figure 109 - The Emergence of A Value Network

## 7.16 Embedded Case Study: Smith Electric Vehicles



Business Model Canvas 25 – Smith Electric Vehicles

Date	Event
1920	Founded as Northern Coachbuilders
1950's-60's	Company prospers through the manufacture of Milk Float electric vehicles.
1959	Secures UK rights to 'Mister Softee' brand and starts producing electric ice-cream vans for UK market in partnership with J. Lyons & Co.
1962	Signs partnership with coachbuilder Boyertown and Exide Battery (both in US) to produce electric delivery truck for US market.
1962	In 1962, there were 14,000 Smith Electric vehicles in operation.
1990s	The rise of the supermarket
October 2004	The Tanfield Group Plc acquires SEV Group Ltd. For £2.2 million and 1 million ordinary shares.
October 2005	Smith Faraday proof of concept vehicle
2006	Smith Launches it's 'Newton' 7.5t truck based on an 'Avia' truck chassis.
February 2007	New production facility opened in Washington, Tyne and Wear.
April 2007	Smith Electric Vehicles launches its Smith Edison

Table 24 - Timeline of Smith Electric Vehicles Development

Despite being a relatively small vehicle manufacturer, Smith Electric Vehicles are the UK's oldest electric vehicle manufacturer. They currently offer a range of commercial electric vehicles.

These are based on volume production vehicles that are converted at their Washington factory.

Smiths also developed a telemetry system specifically targeted at fleet customers (Turpen, 2010) which aims to appeal to fleet managers by collecting information relating to fleet performance, maintenance and battery management. This information can help to reduce costs and improve the performance of electric vehicle fleets.



Figure 110 - An Array of Smith Electric Vehicles; from left to right - Edison Panel Van, Edison Minibus, Newton (No Body)

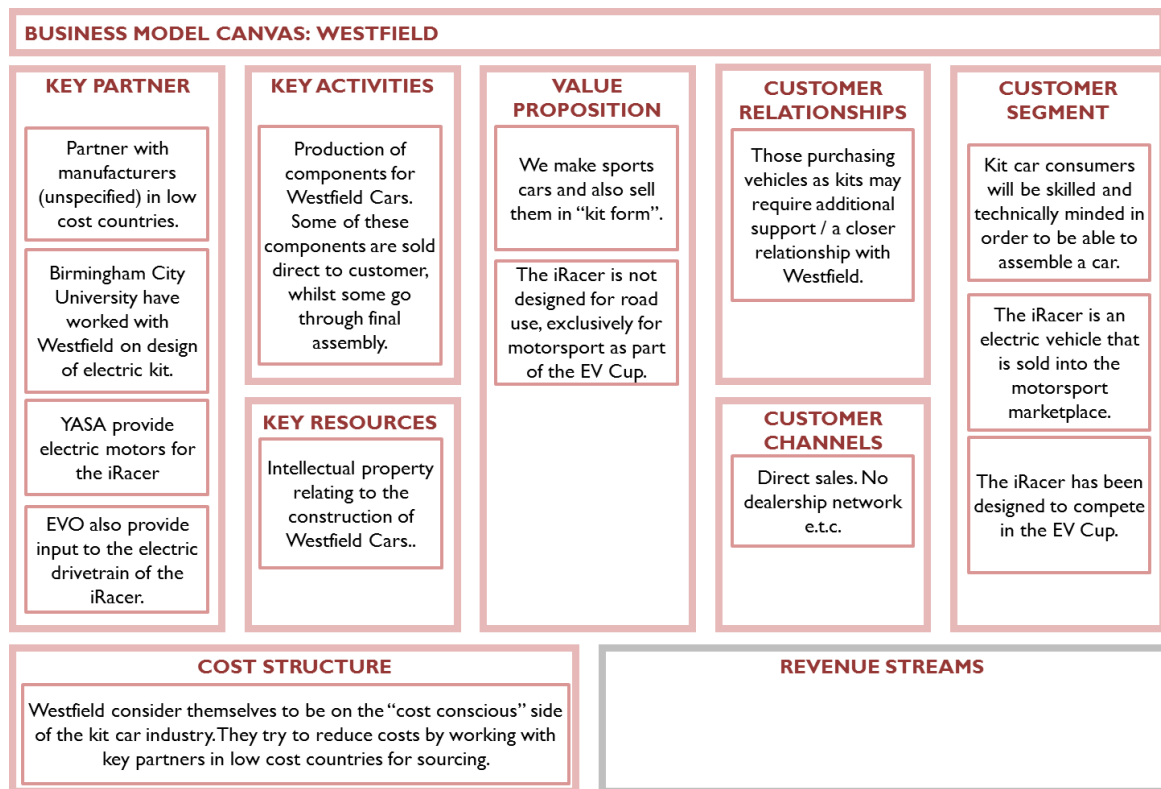
#### 7.16.1 Reverse Takeover by US Subsidiary

Smith Electric Vehicles U.S. then went on to purchase the parent company Smith Electric Vehicles U.K. leaving the Tanfield group with a 49% share holding subject to dilution as additional capital was raised to grow the business. (Morgan K. , 2010)

***“This sale signals a bright future for the electric commercial vehicle industry,” “Being in a position to unify Smith’s divisions after less than two years of operating in the United States is evidence that the market for affordable, sustainable commercial fleets is fertile. The unification of Smith Electric Vehicles will create operational efficiencies and market synergies that will make Smith more financially sound and productive.”***

**Bryan Hansel, CEO of Smith Electric U.S. (Morgan K. , 2010)**

## 7.17 Embedded Case Study: Westfield



**Business Model Canvas 26 - Westfield Business Model**

In 2006, Westfield was acquired by a parent group Potenza Sports Cars – marking a turning point, and entry into the electric vehicle marketplace. YASA supply the electric motors as part of a Evo drivetrain. Whilst the company sources many components from low cost economies as part of a drive to be ‘cost conscious’ within the kit car industry, for the drivetrain components, Paul Faithfull notes that Westfield has tried to stick with British companies and tried to use this to formulate our future car strategies. Westfield produces around 80 factory built cars, and around 120 kits; Paul Faithfull is keen to distance himself from the label ‘kit car manufacturer’ saying that ‘We make sports cars – and we also sell them in kit form’.

In terms of electric vehicles, Westfield have developed an off-road vehicle, potentially as a precursor to a road vehicle. Again, Paul Faithfull notes, *We took the decision that we would develop the technology through the motorsport marketplace* Birmingham City University is a partner in this venture (Dodson, 2013).

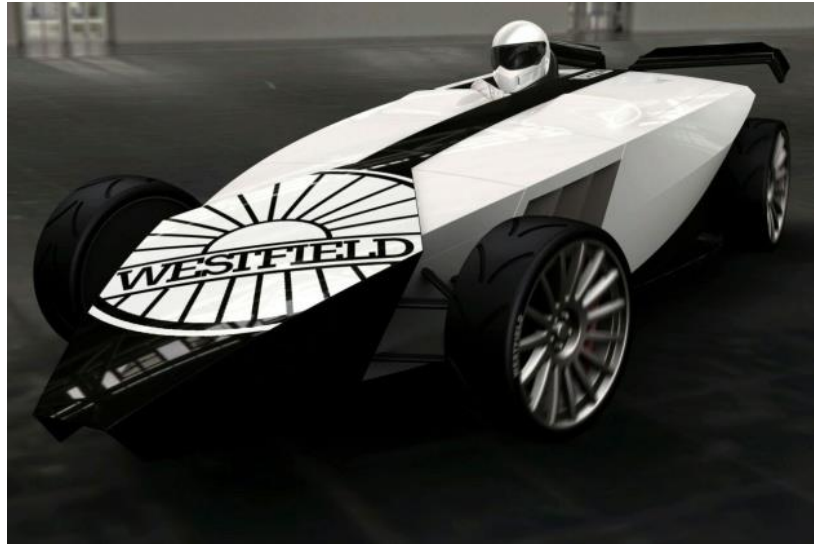


Figure 111 – Westfield iRacer

*Westfield’s direction is focused around strategic joint ventures with companies who have the financial clout and who are based in lower cost economies where we can source components at prices that give us a competitive advantage. We have always been on the more cost-conscious side of the industry – and it has been increasingly harder to differentiate ourselves in this area [...] we are continually looking to improve the quality of the product – but also make ourselves very competitive in terms of pricing.*

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Interview with Paul Faithfull, Westfield Sportscars Ltd. / Potenza Technology

*That is strategically important to us – because if you look at the mainstream manufacturers who can afford to have halo products that they are not making money on – they are introducing more and more interesting products to the market which overlap with what we are doing – they are starting to put “niche” products into the market. Take the MX-5 – it caters to a broad niche; but someone may consider do I get an MX5 or a “Westfield Seven”. Look at the eighties, mainstream cars were very mundane – but now, large manufacturers are introducing vehicles like, say the VW Scirocco, they are also talking about producing a roadster Alfa are talking about a 4C [...] Potentially there are a lot of vehicles that could come on to the market.*

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Interview with Paul Faithfull, Westfield Sportscars Ltd. / Potenza Technology

## 7.18 Chapter Summary

Chapter Seven was a case study comprised of seventeen embedded cases, in the category of what has been termed 'SME (Small-to-Medium sized Enterprise) vehicle manufacturers'. This set of embedded cases was very heterogeneous in terms of the business models employed by the firms under examination, compared to the preceding case of large scale manufacturers where there was a greater degree of commonality in the way that 'Key Activities' and moreover the overall business model was executed.

There was also a much variation in the product offerings, and the technologies that underpin those products – both in terms of chassis / bodywork technology and drivetrain. Some of the products within this case were adaptations of mass produced vehicles. Some, target specific niches. However, there were also some smaller firms with ambitions to challenge the present automobility paradigm. We also see the genesis of some new and novel business models which claim to offer a challenge to the conventional volume vehicle industry's proven formula. At present, the potential of these models is unproven, some have still not migrated from the drawing board (or business model canvas). That said, within the embedded cases, there were a great many interesting ideas which may in the fullness of time challenge, modify or contribute to the prevailing industry business model.

A great diversity was observed in the market niches and customer segments that these small firms are targeting. There were also a number of smaller firms who have a desire to target the 'mass market' with their offering which challenge conventional industry logic. These ventures face a great challenge, as whilst they offer great potential for growth, the task of breaking into a market with such high barriers to entry is a daunting one. It is perhaps this latter group of firms that offered the most interesting comparison with the preceding case study, as these show what new ideas, technologies and business model components are being incubated in SME firms.

Chapter Seven is the second of the two case studies. The content of the two case studies will be analysed in Chapter Eight, with conclusions being drawn from that analysis in Chapter Nine.



## Chapter 8:

### Analysis & Discussion

This chapter synthesises and integrates the empirical data and focuses on a cross-case analysis in order to explore the six research themes and questions. It is important to be mindful, when reading the analysis, that the two cases are rooted in the UK context, which was expanded in Chapter Five.

This chapter specifically focuses on how the empirical work of this thesis relates to the initial research questions. To this end, the structure that is adopted in this section, is to return to each of the sub questions in turn, examining them individually, before returning lastly to reaffirm the over-arching question posed in this thesis.

The theoretical basis for the analysis was established in Chapters Two and Three. The first three research themes focus on how the 'Business Models' theory applies to the cases. The fourth question focuses on the framing theoretical concept of technological transitions, examining how both cases are of firms of different scale involved in the transition to sustainability. The fifth research theme draws together both business models and transitions theory, drawing comparisons and contrasts between the two cases to look at the business models of 'Incumbents' vs. 'Insurgents'. Finally, the sixth research theme builds on the comparison between 'incumbents' and 'insurgents' to look at the relationship between 'product', 'process' and 'business model' design.

In some cases, the empirical data has been deficient in addressing all of the themes that the research questions set to explore. This piece of work set out to be "exploratory" rather than "confirmatory" in nature. So it is to be expected with a piece of exploratory work into an area that is poorly understood that definite answers may be hard to reach. In cases where the empirical data has been unable to provide answers or insight into the research themes, a synthesis of the existing literature has been provided, drawing together the themes explored in the literature review.

Finally, this chapter concludes by looking at how this analysis might speak to a policy audience.

## 8.1 Business Models and the Transition to Sustainable Mobility

*What is the significance of the ‘Business Model’ and ‘Business Model Innovation’ in the transition process? How can we account for the position of the business model in the transitions framework and draw links between these two theoretical models.*

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### Research Sub-Question I

Earlier, during analysis of the theory base for this research, a model of how the business models framework, might integrate with transitions theory was suggested in section 2.7 (p.119).

From the empirical work of this thesis, this particular research question has been challenging to answer. In the main, the reason for this, is that the process of transition in respect to ULEVs is very much in its infancy; the transition has not been observed in its totality. Despite the extended period of observation, it has only been possible to glimpse a “slice” of the early stages of the UK’s transition to ULEVs. The transitions literature and allied socio-technical systems literatures is often applied to retrospective analysis (Mourik & Raven, 2006, p. 2). Perhaps this bias can be explained because hindsight of transitions allows for reflection upon their complexity in the round more readily than trying to evaluate the nature of complex dynamics whilst they are ongoing, and whilst the observer is in the midst of this dynamic change.

That said, from the evaluation of the theories of both transitions and business models, it has been possible to construct a model of how the ‘business models’ concept interfaces with the ‘transitions’ concept. This insight is novel, and is based on the connections between the literatures reviewed.

This theoretical linkage is crucial to the construction of the theoretical perspective of this thesis. However, it has been hard to demonstrate the theoretical linkages proposed solely through the case-studies and empirical data examined in this thesis. For this reason, in a number of instances, anecdotes and pen-portraits from other industries and sectors have been used to support this underpinning theoretical development.

### 8.1.1 Relating the Business Model to Transitions

The contribution of this particular piece of theory development, is in applying the “Business Models” concept to a multi-level view of transitions, in order to interrogate some of the socio-technical interactions at a finer level of detail than is offered by the macro-level multi-level perspective.

As Chesborough and Rosenbloom (2002) observe, the business model mediates between the economic and technical domains. The economy is socially constructed and determined by the will of social actors; therefore, the business model would seem to be perfectly positioned to explain the socio-technical interactions of firms on a micro level within the multi-level perspective.

When we look at the multi-level perspective, we see actors actions represented as a series of arrows, coalescing to form a common direction of transition. The ‘business model’ framework, combined with a knowledge of strategy explains “the arrow”. The transitions framework explains what forces are acting on the arrow, but the business model (which is informed by strategy) informs the logic that underpins how the arrow is going to move. Strategy, in this analogy, would be the thinking that goes behind how to configure this “internal business logic” in order to best respond to these outside forces. Of course, with the business model ontology, two components “Key Partners” and “Customer Segments” refer to something that is not wholly intrinsic to the business. For this reason they have been highlighted grey – this signifies that whilst the decisions taken by the business about what actors to engage with are internal, the “Key Partners” and “Customer Segments” themselves are extrinsic.

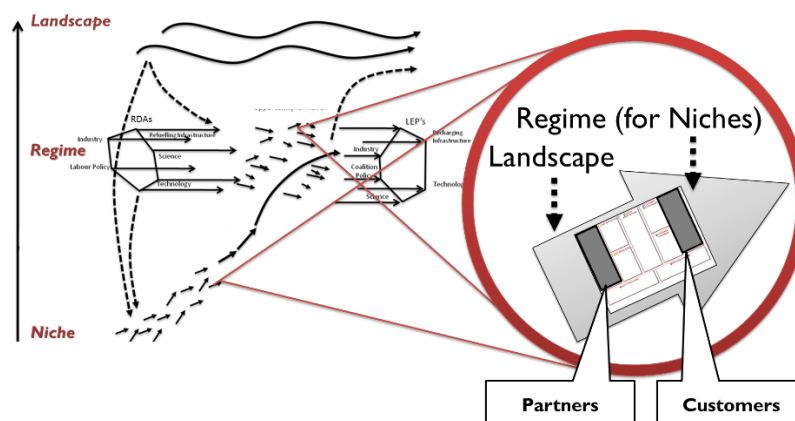


Figure 112 -The business model explains the logic of the firms engaged in transition

### 8.1.2 The Value Proposition in Transition

The value proposition is central to the business model and mediates between the two sides of the business model canvas: value creation and value capture. It seems therefore a logical place to start.

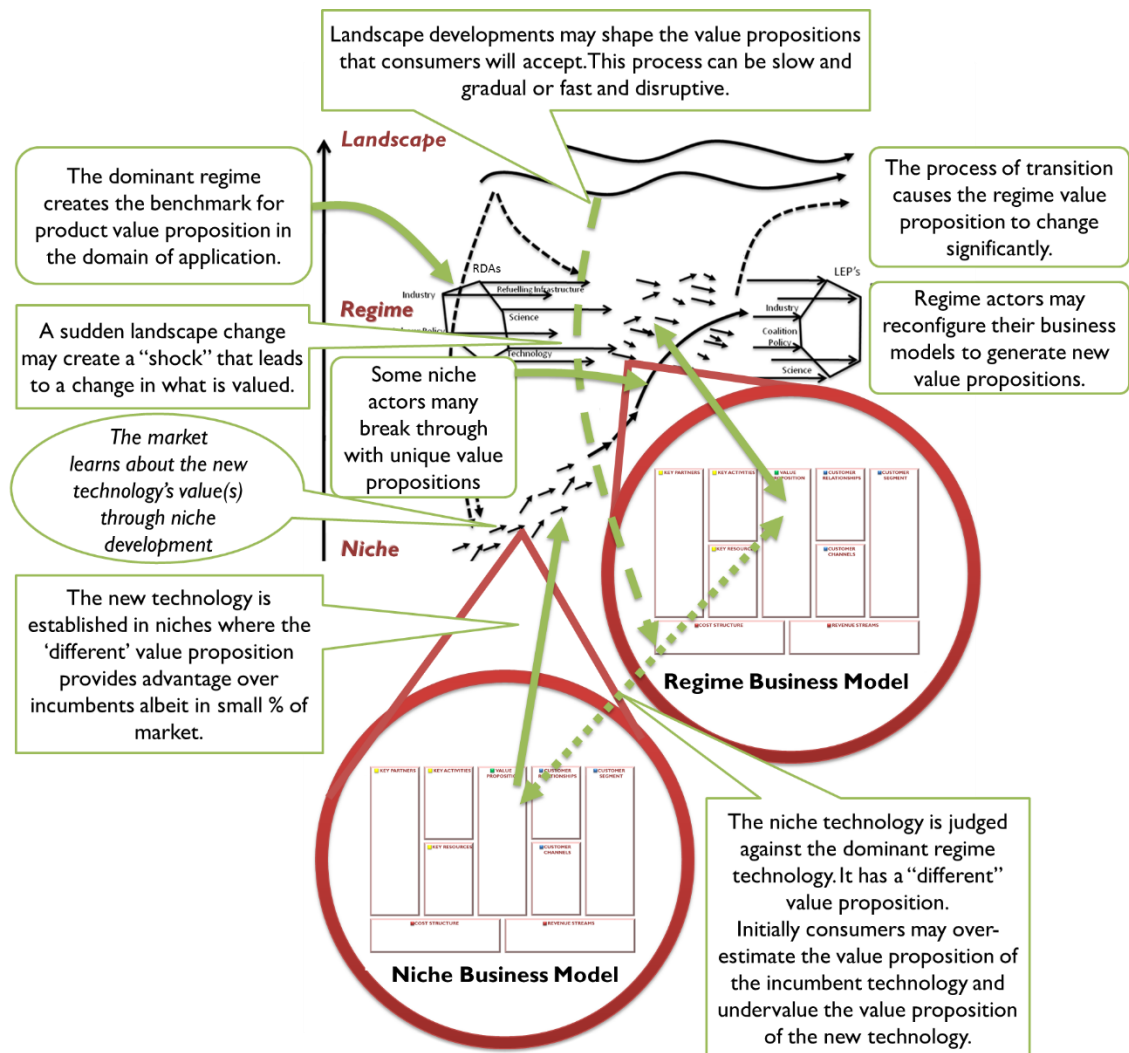


Figure 113 - The Value Proposition in Transition

The technology that is dominant in the regime is the benchmark for the customer's perception of value. We see through the work of Gourville (2006) (explored on p.80) that there is often a mismatch between customers' beliefs in the value of existing technologies and the belief of innovators in the value of their novel innovations. New technologies offer different value to customers over existing technologies and there is a process of social and cultural adjustment for consumers to appreciate the values of new technologies. This is a learning process. The learning process comes with a cost, that the customer must invest time and money into gaining experience with the new technology. Early

developments of the technology may not offer a sufficient improvement in value proposition for consumers to make this investment. However, over time, technological improvement goes hand in hand with customers learning about the gradually improving technology value propositions.

There are however niche markets, for which the existing 'challenger technology's' value proposition is sufficient to meet 'niche market consumer expectations' adequately. Challenges with the existing technology create an appetite for experimentation with new technologies that offer the potential for improvement. As niches establish and prove the technology, more and more people become aware of the benefits of the technology and are prepared to invest time.

This learning process about the value proposition of new products not only concerns consumers, but also the manifold institutions and actors that constitute the socio-technical regime. The learning process also includes political and governance actors. These require proof that regulatory regimes and social structures should adapt to the new technology and that the new technology is necessary.

Using an example from a different domain; video tape technology which only offers "sequential" access to video content, and whose quality degrades with repeated playback offers a poor technology fit for 'museums' and visitors centres who want to show repeated short clips of video. Here was an opportunity for an early-market for optical disc, laser disc and DVD technologies to establish a foothold, as the value proposition of the new technology provided significant advantages in this niche application. People begin to gain experience of the technology and this learning process informs a range of consumers' decisions about the potential value of the new technology. It may be that a museum curator, who worked with a "laserdisc" display system in the workplace, then becomes aware of the technology's advantages and is a potential early-adopter of laserdisc technology in the home. Gradually perceptions of the value of the new technology are changed by learning.

Other actors, as well as consumer of the technology also need convincing of the benefits that the new technology offers. An example here might be "video rental stores" making decisions about whether to support VHS, Betamax standards or more latterly Laserdiscs, DVD's and BluRay. As social actors coalesce around a new technology, they begin to create momentum and potentially lock-in.

It may also be that there is a “landscape shock” which dramatically changes consumers’ opinion about the value proposition of new technologies versus old ones. This could lead to the radical transformation, reconfiguration and dealignment-realignment transition pathways explored by Geels & Schot (2007). Potentially, there are landscape shocks which are temporary in nature – and momentarily shift perceptions, but their effects are not enduring or sufficient to prompt radical change. An example here might be the Suez Oil Crisis, 1970’s oil crisis – which briefly resulted in the production of more efficient vehicles, but did not prompt a total transition of the regime.

Alternatively, landscape shocks, or cumulative small events can lead to a softer more gradual process of reconfiguration in which the regime adapts, or evolves. Over time, the regime comes to realise that the customers’ values and priorities have changed, and will either introduce new technologies with a value proposition that appeals to customers in the changing marketplace; or may be unable to adapt to the new changed socio-technical configuration. Consider the changes in photography – camera brands like Nikon and Canon adapted to the changes in photographic habits by consumers, gradually introducing new digital cameras, which would sit alongside their film cameras and be able to share some lenses and accessories. Their business models proved durable as they offered a value proposition to consumers that fitted the emerging new socio-technical regime of digital photography. Other companies such as Kodak could not make incremental changes in the same way with their technologies of film production becoming redundant. They had to effectively completely re-invent their business model by discarding old processes of film manufacture and forming a radically new business model based around cheap inkjet printing whose value proposition would appeal to consumers in the new socio-technical landscape.

Perhaps what is even more interesting, and not considered in the literature, is transitions from “regime” to “niche”. Ilford, were one of the leading manufacturers of black-and-white photographic film, papers and chemicals when wet process photography was considered the dominant socio-technical regime. As digital photography has displaced wet processes as the dominant socio-technical regime, a brand that would once have been considered part of the “regime” has adapted in some ways; offering high quality photo quality printer papers; but in many ways has retained the traditional products for which it has built a reputation – and sells them into a niche market.

The value proposition sits at the centre of the business model, mediating between on the one hand the “value creation” side of the business model, and on the other hand the “value capture” side of the business model. Shifting value propositions may necessitate changes in one, or both sides of the business model.

It may be, that for some socio-technical transitions, the complete business model does not require reinvention. Relating back to the case of “home video”, as it is a simple case which is easy to relate, consider the transition from magnetic tapes, to optical discs to modern streaming films over the internet. Three distinctly different socio-technical regimes, with different value propositions:

In the first transition from magnetic tape to optical discs; the value proposition still revolved around a physical artefact, the tape or disc, but the socio-technical regime transitioned significantly from one dominant technology to another. It can be seen that the “value capture” side of the business model changed very little though. The whole socio-technical regime was based around sales of players to consumers, sales or rentals of physical media which could be played. But essentially, the value capture side of the business models that supported this socio-technical regime could remain constant. Retailers still sold the electrical goods, the VCRs and DVD players. They also sold the blank or pre-recorded videos. Rental stores like “Blockbuster Video” kept their names, but simply changed the type of technology – renting DVDs rather than videos.

Now, in the second transition from optical media to “streaming on demand video”, both sides of the business model look radically different. The “value capture” mechanisms change. Instead of changing the “value creating” components of the business models – the suppliers of technology, the intellectual property and physical manufacturing equipment. Instead, the value capture side of the businesses in this socio-technical regime are forced to change content is available on non-specialised devices, the distribution channels and customer relationships are dispensed with in favour of online distribution.

In this case some of the actors in the socio technical regime were able to adapt. The film studios kept producing films but started making new Key partnerships with new companies that could offer new customer channels. Some regime actors however would not have been able to transition; Blockbuster Video (Davis & Higgins, 2013) and other rental stores being a notable recent casualties. Instead, some

of these actors that constituted the previous socio-technical regime were displaced by new insurgent niches with a radically different business model. This model disrupted the socio-technical regime and all of its sunk investments and inertia by radically reconfiguring the way that the “value capture” side of the business model was configured through both dematerialisation of the business model (removing the physical artefact) and changing the customer relationship and channels dramatically.

Here, the key point is that the ‘value proposition’ changed dramatically as a result of changing technology. However, the ‘business model’ is what transformed this technological change into a socio-technical change by providing an underpinning economic logic that consumers ultimately found appealing. In the first model, the economic logic behind exploiting the technology was the simplest of all – the consumer purchases a physical technological artefact that produces some function (video playback) and the media this technology consumes (tapes / discs). In the streaming video example however, the value proposition and its economic underpinnings are radically reconfigured. No physical media artefact, disc or tape is purchased or consumed – but instead, the content is provided wirelessly as a service for which a subscription fee is paid. This may be viewed on a dedicated “smart TV” or other device solely intended of the consumption of media. However, with ‘digital convergence’ this is not necessary, with the potential for media to be viewed on a phone or computer, which fulfils a much greater range of functions than an old dedicated VCR or DVD player.

This change in value proposition, is at the core of the concept of “Product Service Systems” (p.168), which underpin some of the more divergent and challenging business models explored in this thesis. On the one hand, from the ‘regime’ is the Peugeot “Mu” concept, however, within the embedded cases is the “Riversimple” (p. 349) case study. There has not been a large-scale transition in the vehicle industry towards consumers purchasing mobility as a service.

That said, in some other sectors, there is evidence of businesses ‘dematerialising’ products, and switching to ‘product service system’ (see page 168) models. How readily transferable these models will be to automobility in practice remains to be seen. There are other unanswered questions - are consumers ready to relinquish ownership of vehicles in favour of automobility as a service? Will regulatory regimes adapt and evolve to incentive automobility as a service, when production and exports contribute so much to national economies?



### 8.1.3 Value Creation in Transition

The value creation dimension of the business model in firms that are part of the dominant regime tends to be conservative and echo others in the same industry. This is part of what Wells & Nieuwenhuis (2012) term ‘institutional isomorphism’ In stable regimes that are undergoing incremental change business model refinements seek to ‘optimize’ value creation processes through efficiency – rather than competing through any sort of disruptive innovation. In stable technical regimes, consumers have expectations about the nature of the product and the price it should be; therefore the lowest risk value creation strategy is to stick with proven technologies, but refine them to engineer out excess cost and inefficiency.

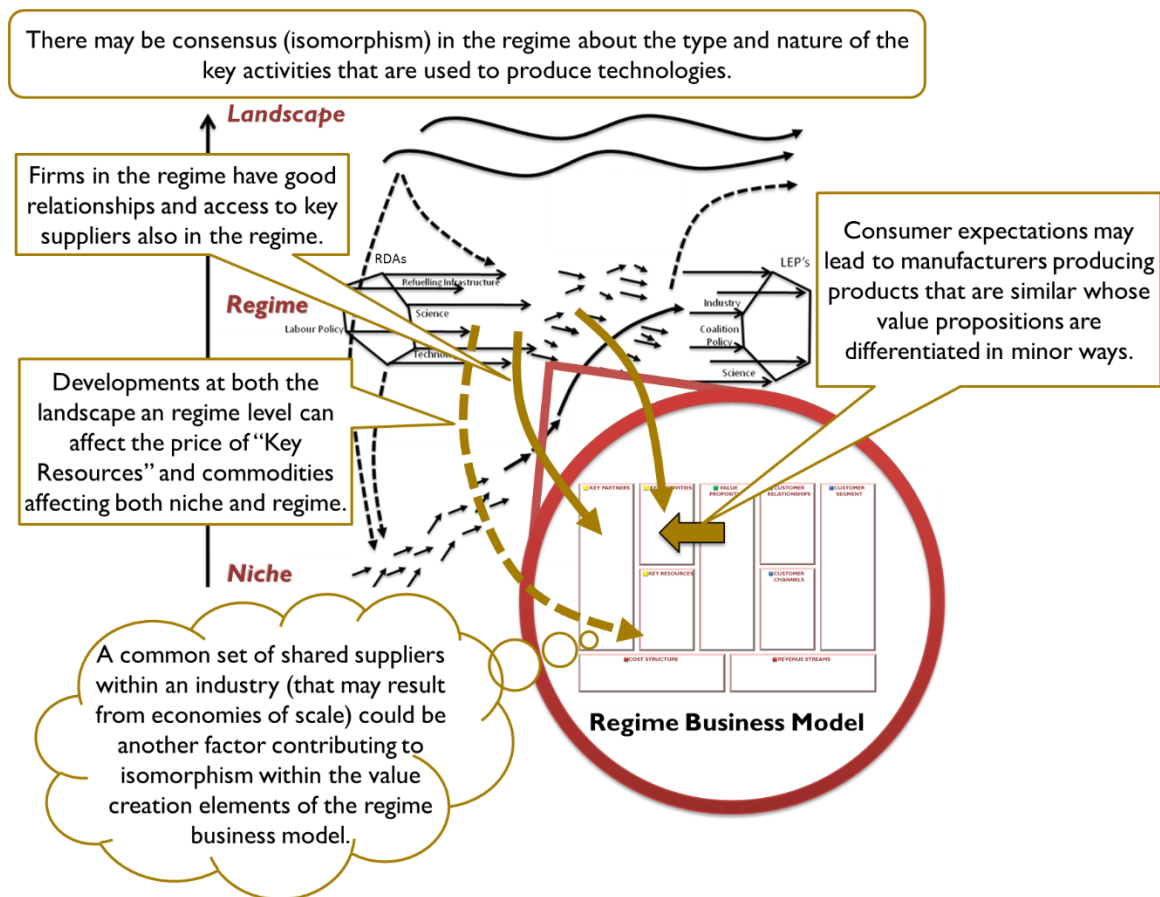


Figure 114 - Value Creation within Regimes

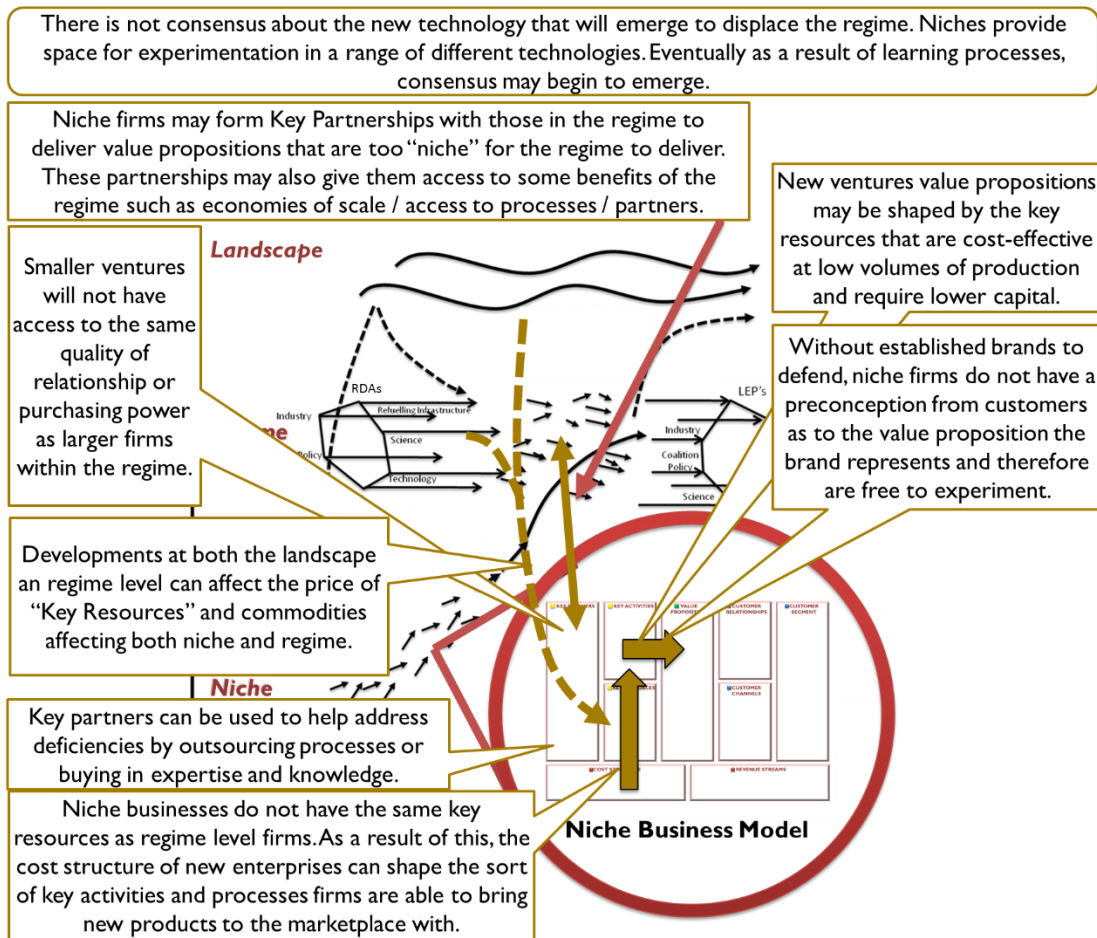
What this means in the automotive industry, is that there are a wide range of manufacturers producing similar products, using a similar technological formula. Around these vehicle manufacturers, there are tiers of suppliers that manufacture modules and component parts which in turn supports lock in.

These suppliers, produce parts that are sold to many different OEM VMs, and therefore they are engineered to have a degree of generic compatibility to enable their use in different vehicles. This encourages technological monoculture. Standards and norms become adopted in industries to allow interchangeability. With Key Suppliers producing goods for a range of manufacturers and Key Activities being carried out in a very similar way in different firms around the world, it is unsurprising that the Key Resources that firms operating in the industry possess share many common features.

Overarching this stable regime of value creation, is the landscape. Here, the landscape can cause disruption for the regime. Consider the Suez Crisis and 1970's oil shocks. These both put pressure on the regime by changing the value proposition that consumers would find appealing, and changing the availability of key resources. This caused the regime to temporarily shift the emphasis of its production to smaller vehicles – and we see the emerge of bubble cars and a range of small vehicles like the Bond Bug as a response to this temporary landscape shock – however, the duration of the shock was not sufficient to cause any real transition in practices in the regime.

There is also slow sustained pressure from the landscape, say in the case of gradual oil price rises. Within the motor industry, we have seen the regime respond to these landscape developments by slow, incremental innovation, gradually increasing the environmental performance of vehicles to adjust to these landscape pressures, by improving the efficiency of existing engine technologies, light weighting with high strength, thinner steels that can still retain the production processes in which there are sunk investments, as well as making other components within the vehicle lightweight. This extends the life of the regime.

Attention now turns to how niches create value within the business model. Starting from scratch, niches do not have the capital or resources of the regime, however, they are also unencumbered by the expectations and desires of the marketplace. They do not have brands to defend. However, niches can also ride on the coat tails of the regime's value creation processes – by taking regime products and re-engineering them to suit niche markets. This also gives the niche access to some of the economies of scale of regime activities. This is discussed in the diagram overleaf.



**Figure I 15 - Niche Value Creation Business Models in Transition**

Note one key difference between the two preceding diagrams. Actors within the incumbent regime have to manage the expectations of consumers who are familiar with its product and expect conformity with other similar products in the marketplace. Why were Robin cars derided by consumers? They had three-wheels rather than four, and were made from GRP not pressed steel, and were therefore viewed as inferior or somehow not fitting within the norms of the market. Therefore, in the value creation dimension; norms and expectations about the value proposition of regime VMs influences the selection of Key Activities. Niches may dare to be different, they can experiment with ideas that do not fit with the regimes norms. Furthermore, the value proposition of niche products is more likely to be constrained by the key activities available to the niche that in turn are dictated by the cost structure of establishing a new business. This disqualifies processes that are capital intensive in nature; accounting for the proliferation amongst niche vehicle manufacturers of composite technologies, which whilst more labour intensive requires less capital investment.

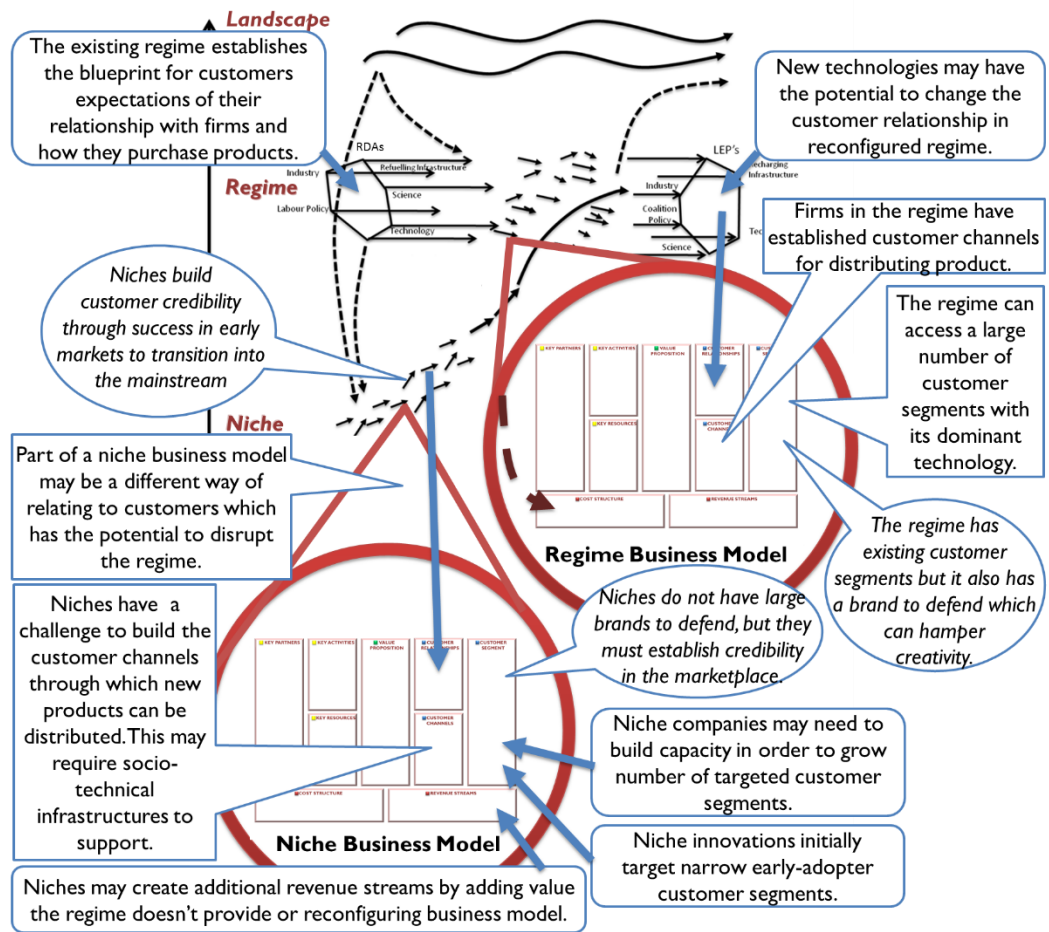
Another key difference with niche vehicle manufacturers, and niches more generally, is that being small and new, they do not have access to the same quality of relationships with Key Partners, in this case tiers of suppliers, that regime actors with an established track record and large quantity of business have. This might cause niche actors to seek out different partnerships with alternative key partners that are potentially outside of the regime. These niches may in turn agglomerate to form larger niches or niche-regimes. Alternatively niches may form partnerships with regimes.

Most interesting of all however, is business models where there is translation between the value creation models of regime and niche actors. Where either a niche manufacturers value creation strategy is reliant on a regime manufacturer, or even more so – and from a transitions perspective this is especially interesting, where a regime manufacturer embraces a niche business as a key partner.

Within the case studies there are ample examples of the former, with Allied Electric Vehicles, the Electric Car Company and Smith's Electric Vehicles, all taking a base vehicle from a volume manufacturer – but altering the vehicles value proposition through retrofitting ULEV drivetrain technologies. Here the niche firm gets access to many of the benefits of scale of the value creation process that comes with being part of the established regime. The benefits of manufacture in volume, a function of the key activities, the benefits of large scale sourcing arrangements with Key partners and also the key resources of a big firm. Here value is added through alteration and modification.

The latter however, is particularly interesting – and from a transitions perspective, shows evidence of how ideas from the niche can make it into the mainstream. An example from outside the embedded cases might be the now defunct partnership between Renault and Project Better Place. Here, a large VM that is part of the regime, embraced as a key partner a niche start up business, and designed its product's value proposition around the new niche technology. Similarly, whilst not a ULEV, we could point to the contract manufacture of the Vauxhall VX220 by Lotus. Here, the value capture side of Vauxhall's enormous business model, is united with a niche VM's value creation business model.

## 8.1.4 Value Capture in Transition



**Figure 116 - The Value Capture Side of the Business Model in Transition**

The right hand side of the business model canvas refers to the ways that firms capture value from their product. Viewing the types of business models that firms deploy at different levels within the multi-level perspective, it should seem self-evident that those firms existing within the regime have well-developed infrastructures for value-capture. This side of the business model can comprise the technical systems for logistics, physical dealer network and other technologies that form its customer channels; but also to be considered in this same element of the business model are those social-dimensions, the brand-presence of an established name, the social networks and infrastructures that support the brand, the awareness, the human resource and the historical relationships companies have with their customer. This contributes to the sense of inertia in the business model. Much as companies may be reluctant to abandon “key resources” in which they have invested significantly, they are also reluctant to tarnish relationships which have taken time to build and nurture.

This is the incumbents curse – not wanting to experiment too radically or try new things for fear of alienating the loyal. By contrast, looking at the business models of those within niches; the “value capture” dimension to the business model is often quite immature. It has to be built from scratch to support the new innovation. The customer segments targeted at first are those in the early market who have a need or desire for the particular niche innovation that predisposes them towards experimentation with the new innovation. The present technology does not quite meet their needs, or being ‘innovators’ they are keen to trial leading-edge technologies. At the early stage of the transition, the technology might be crude, but the early market is forgiving. It is through these learning processes that experience is gained with the novel technologies. The customer relationships have to be built from scratch with the new brand.

Where niche ULEV makers have an advantage in this respect, is that producing ULEVs on a small scale imbues them with a quality that the regime cannot possibly replicate – rarity and uniqueness. In many cases this has been used by niches to their advantage. Considering the cultural dimensions of the UK carscape (p.219) an automotive culture that prizes individuality, novelty and rarity has encouraged the growth of a large number of niche companies within the UK – some of which, whilst small have managed to build “niche-regimes” and create enduring business models.

Niches can spot customer segments that are small, but clearly defined and create value for these segments in a way that large regime concerns do not have the flexibility to accommodate. However, volume manufacturers have realised the degree to which niches encroach on their territory – through more flexible attitudes towards value capture the attitude of large VMs is slowly changing and this research shows that there are some emerging, innovative approaches to value capture that have the potential to grow.

***The innovation now, I think, is coming in the way we market rather than the way we manufacture or distribute.***

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**Interview conducted for this research, with Denis Chick, Vauxhall**

## 8.1.5 The Cost Structure In Transition

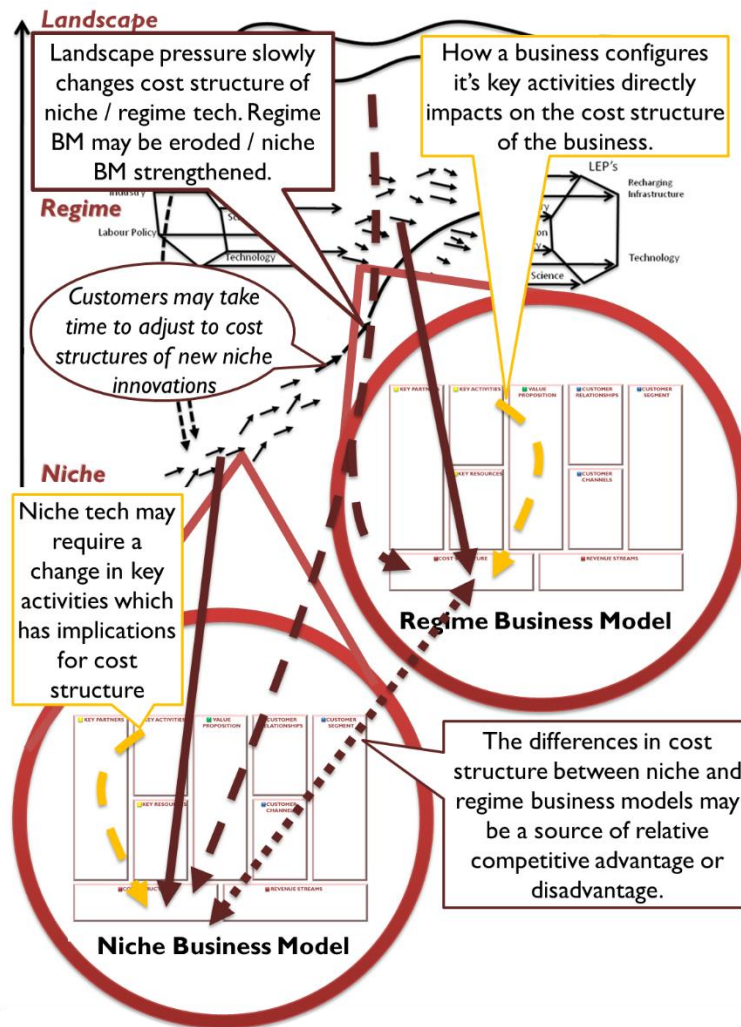


Figure I 17 - Cost Structures in Transition

Incumbent businesses cost structures are defined by their utilisation of resources and the processes they use to produce products. A niche technology may have a dramatically different cost structure. Some of this may arise as a result of diseconomies of scale; changing as the technology gathers momentum and is adopted into the marketplace. Alternatively, the product may have a dramatically different cost structure because the processes, techniques and materials used are radically different. This presents a tension in the relative competitive advantage / disadvantage of the niche business model in relationship to the mainstream regime business model.

If the niche can provide clear cost leadership over the incumbent regime, then the transition may gather pace quickly. An example here from a different domain could be the introduction of Voice Over

IP technologies in telephony. VoIP calls to international customers are significantly cheaper than over standard telephone lines. The cost of equipment is relatively modest, so there is a clear rationale for transition. Services like Skype have been able to erode the market place of traditional telephony as there is a clear cost advantage that is easy for the customer to understand.

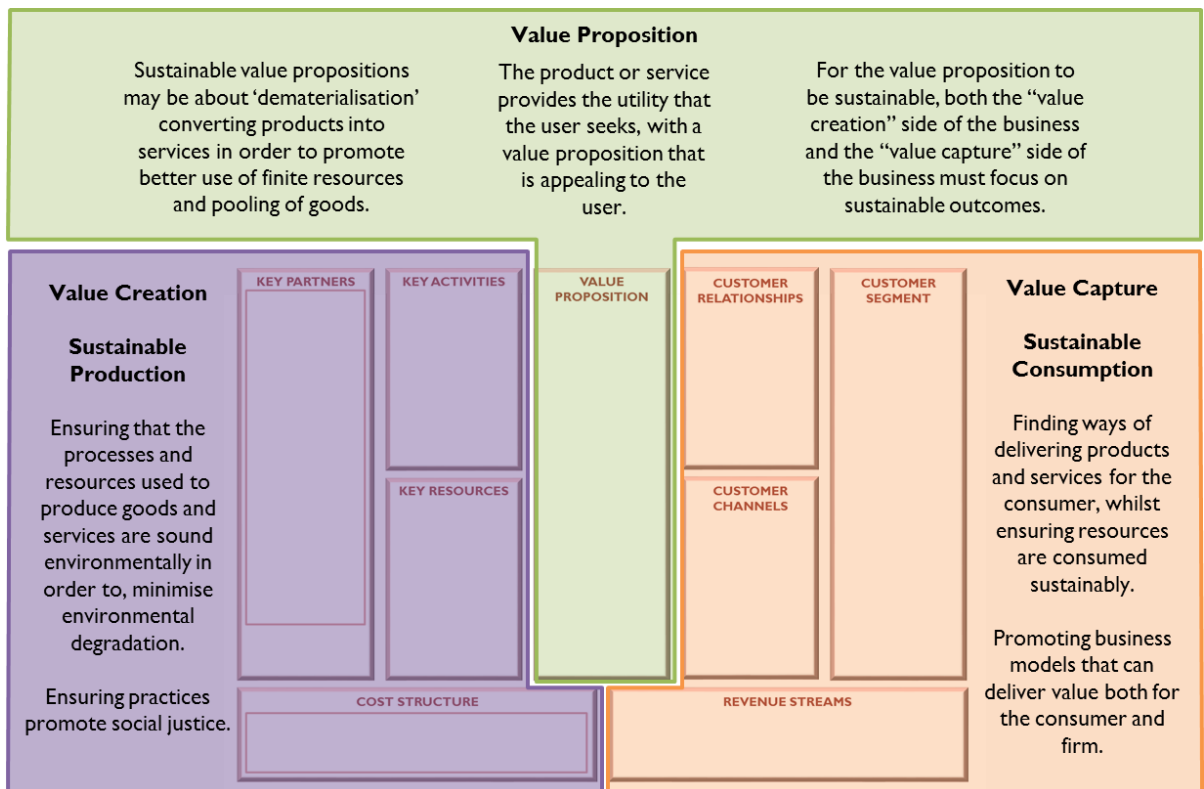
In the field of ULEVs, the cost structure of the product is radically different to conventional vehicles. The capital investment is much higher, however, this is recouped over the total cost of ownership. What makes the transition harder for customers is that there may be social and cultural factors also involved in the customer's perception of the vehicle cost. For example, we have a culture amongst some new car buyers, of regularly changing vehicles – here, depreciation means that the customer's perception of the value over the total period of ownership is different. Culture and society may need to adapt and change to the cost-structures of the new niche business model. Or the niche may need to adapt and find creative business model solutions to mediate between the benefits of the new technologies and the economic differences.

The main game-changer for the cost structure of ULEVs, is the power storage – whether this be hydrogen fuel cells, or batteries. In the automotive sphere, there is evidence that a number of firms are offering battery rental schemes or credit arrangements to help consumers who cannot amortize the initial capital cost of a vehicle battery. Furthermore, within the UK, we see Nissan attempt to capture value from this cost, through the construction of their own plant for the final assembly of battery modules. We don't see any firms in the UK market engage with the business of raw cell manufacture. It is interesting however, that on the other side of the Atlantic, Tesla, an insurgent niche firm has bold plans to engineer the cost out of EV batteries in what potentially could be a radically disruptive move that could change the industry. In the UK, the smaller vehicle manufacturers have not managed to manifest the capital to engage in such a venture. Here however, there has been another opportunity in the value chain for Axion to act as an intermediary, taking cheap imported cells, and adding a level of quality assurance. This may not result in the lowest overall cost, as an intermediary is involved, but it has given these small EV makers access to quality cells.



### 8.1.6 Relating the Business Model to Sustainable Production and Consumption

Sustainable consumption and production considers the relationship consumers and producers. Within the business model ontology, there are two distinct sides to the business “value creation” and “value capture”. The combination of these two sides of the business model result in the overall “value proposition”. For an innovation to diffuse, it has to create a value proposition that engages consumers. For consumers to transition the product has to fulfil consumer expectations about not only the function, but also the aesthetic of the product or service. This is a delicate balancing act, and successful sustainable business models need to master all of these dimensions.



**Figure 118 - The Sustainable Value Proposition: Considering Value Creation & Capture as dimensions of Sustainable Production & Consumption.**

Approaches to sustainable business often focus on the “value creation” side of the business. The challenge is engaging businesses with more sustainable models of “value capture”; business models that are focused around shifting physical products are natural orientated towards encouraging consumption in order to sell product. More sustainable business models will seek ways to dematerialise, including product service systems.

## 8.2 Business Models in the UK Car Industry

*What ‘types’ of business model can we identify in the UK marketplace? We can suppose that scale in terms of production volume will be one of the major factors differentiating the business models that firms deploy; however, what other factors can we use to differentiate and understand business models. What evidence is there for innovative business model configurations and components being deployed in the UK car industry?*

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Research Sub-Question 2

### 8.2.1 Mainstream Manufacturers ULEV Business Model

Outside of the UK context we can see in the example of BMWi that there are mainstream manufacturers who are prepared to consider a radical reconfiguration of the ‘value creation’ dimension of the dominant automotive business model.

Within the UK context examined, the introduction of ULEVs, is changing manufacturers’ business models in more subtle ways and there is no evidence of any dramatic transformation of the bodywork technology that underpins the present dominant business model formula.

As has already been argued, from the decision to use pressed metalwork many other business model choices flow. That said, given that there are a significant proportion of “premium” manufacturers in the UK, many are working with aluminium rather than press-steel leading to lighter weight vehicles, however, in sustainability terms, this is offset by the notion that premium vehicles tend to be larger and therefore heavier to start off with. With the growth of the premium compact sector, and announcements of vehicles like the Jaguar XE and its aluminium architecture, there may be platforms and vehicles on the horizon, that are both compact, and make use of lightweight vehicle technologies that offer a greater advantage to ULEV drivetrains.

The value creation dimension of large firms’ business models in the UK remains relatively stable. What is changing significantly in respect of ULEV manufacture, is the new key partnerships that manufacturers must use to source new technologies.

Whether vehicles are based on EV or hydrogen technologies, the drivetrains ULEVs employ are significantly different to those currently embodied in vehicles. Particularly in the domain of battery and fuel cell technologies. Here are capabilities that are outside of the current supplier tiers that commonly used by the vehicle industry. Large VMs are starting to look outside of the established socio-technical regime for solutions. Most interestingly is the case of Nissan that has decided to establish battery manufacturing in the UK and has purpose built a factor to supply these battery modules. Given that component manufacture is in many ways a more significant process for value creation, this can be viewed as a significant development which shows that the regime is beginning to adapt.

There are also some interesting interactions between niche manufacturers and the regime, in particular Jaguar Land Rover created a significant buzz in the work with Bladon Jets on the C-X75 concept vehicle. This is another example of manufacturers tentatively exploring Key Partnerships outside of the regime. Jaguar in particular has invested heavily, and been supported by the TSB to explore a range of ULEV projects that bring together the volume manufacturer and niche companies. However, on the whole, these are still small tentative steps – perhaps more symbolic of a desire to explore alternatives rather than indicative of a substantive market transition to them; although there is much promise for the future.

There may be some minor changes to the customer channels used to distribute ULEV vehicles. Outlets specialising in ULEVs in key locations have been created with specialised sales staff. Strategies may be put in place to target the customer segments that manufacturers feel will be early adopters. However, by and large, these changes are small variations on the mainstream automotive industry's business model, rather than a radical reconfiguration.

Whilst the UK is an early market for Electric Vehicles for many, there are still other markets which appear to be a more vibrant hotbed for manufacturers' innovation than the UK. Particularly, in California, there appears to be more appetite for manufacturers to experiment – perhaps because of a greater culture of innovation and pressure from the regulatory regime.

There are some particularly interesting developments from UK VMs, in some of the digital initiatives by Large VMs. These are new innovations enabled by smartphones, the internet and changes in digital culture. Initiatives like Jaguar's work with IBM on creating virtual digital environments for customers to experience their vehicles- or Nissan's creation of virtual EV charging for the players of "Sim City". These are small changes, but show that manufacturers are starting to engage with innovative ideas about reaching their customers.

Looking to the global marketplace, manufacturers such as Peugeot experimenting with initiatives like Mu, BMW experimenting with the BMWi brand (which has strong links to the heritage of the parent brand, but also articulates a separate sub-brand specific to low carbon mobility) and General Motors looking at some radically different mobility concepts like PUMA show the first signs that the regime is starting to consider mobility concepts that appear different to its existing business model.

Hill & Rothermael (p. 15) – as explored on page 85 of this thesis – note that some large incumbent firms can prosper despite the appearance of radical technologies. One of the factors they attribute to the success of incumbent firms capitalising upon new innovations, is the establishment of 'autonomous divisions' – *'protecting the nascent technology from political opposition and other forces of inertia within the enterprise'*. In the cases above, this has been the case, where separate departments or brands have been established to manage new approaches to mobility.

There are radical ideas out there, which are starting to take root in the mainstream industry. However, in terms of "transitions" thinking, these ideas are still embryonic, and we are only witnessing the very genesis of a transition in the industry.

That said, there is now also a growing case-book of failed initiatives, which are an inevitable part of any disruption, but perhaps caution some against innovating too quickly. The failure of Project Better Place, which was considered by many to have so much promise in overcoming the range anxieties associated with electric mobility is likely to have caused many in the industry to consider caution before engaging with key partners with new business models, as Renault has done so boldly.

### 8.2.2 Low Volume Performance ULEV VM

The UK has a long history of small, independent vehicle manufacturers releasing low volume production vehicles. In section 3.5.2 Low volume specialist assemblers on p.151 we examined the UK's historical context of small, low volume sports car producers. Often these ventures were undercapitalized, and many have failed over the years. Some marques however have prospered.

According to Rhys (1977, p. 318) smaller producers rely on “...the demand for their differentiated product being strong enough to cover the basic increase in costs due to ‘inefficiency’ and due to increased factor inputs”. In another article, Rhys (1977, p. 247) states that “differentiation is the reason for entry of survival” as far as small firms are concerned. These basic truths still hold true.

Within the “Performance” VM category, those that have plans to introduce ULEV performance vehicles are doing so on the basis of a straightforward sales transaction, for which the unique ULEV will command a premium price, there is no evidence in this type of firm of consideration of business model innovation in the value capture side.

However, Lotus, has created an additional revenue stream, out of licensing its low volume performance car know-how to other companies (explored later in ‘new’ business models).

Focusing on the business model of these ventures as ICE vehicle producers, Ginetta, Lotus & Morgan can all be seen to have evolved from this lineage – and over time, the brands of these respective firms have matured and grown, so that having endured the turbulence of the UK motor industry and proven themselves they are no longer considered fly-by-night companies of modest means, but an accepted and enduring part of the UK automotive stable of marques. Whilst Westfield is a slightly more recent entrant in 1982, it too has established some history for itself. As ICE vehicle producers, the business models of these marques have proven themselves to be relatively durable; and the business model of low volume production is essentially that of p.151.

In this respect, Lightning is a new introduction. It shares some heritage with Ronart, however, is a completely new product manufactured using radically different processes.

### 8.2.3 Low Volume Commercial ULEVs

The commercial sector has proved a fertile market for ULEVs in the UK. On the one hand there are firms like Allied and Smith Electric Vehicles who have built businesses around vehicle conversion- leveraging some of the benefits of using a volume VM as a key partner, but retrospectively adding ULEV value.

On the other hand, Modec is interesting as a company that introduced a new commercial vehicle, that was designed from scratch. What is particularly interesting here is how the QFD process was deployed in order to arrive at a vehicle solution that in many ways differed from the typical classes of van and commercial vehicle seen in the UK marketplace at that time. Certainly Modec's vehicle has enjoyed some success, and a number of large companies deployed fleets of Modec's vehicles. Ultimately however, the Modec business model failed? Perhaps here, there is an interesting observation and commentary on the costs and risks associated with introducing a vehicle based on a completely novel design, which requires expertise and skill in many areas, considered against the alternative business model of using a volume VM as a key partner.

From a sustainability perspective, the latter represents a compromise as existing vehicle technologies are heavy weight, and not necessarily optimised towards ULEV drivetrains. However, it is also the route that Vauxhall are investigating with their Vivaro van prototype.

What we haven't seen in the commercial vehicle sphere yet; is a manufacturer looking to manufacture a commercial vehicle with lightweight bodywork technology. Perhaps Modec with its aluminium chassis could be considered a step in this direction. It will likely take a significant amount of proving in passenger vehicles, before these bodywork technologies trickle down to the commercial vehicle sector, however, they would represent a more optimised, sustainable vehicle were they to come to market.

Whilst Bee Automobiles never really got off the ground in terms of productionisation and vehicle manufacture, it is interesting that a commercial variant of the Bee One was also considered.

## 8.2.4 Vehicle Conversion BM

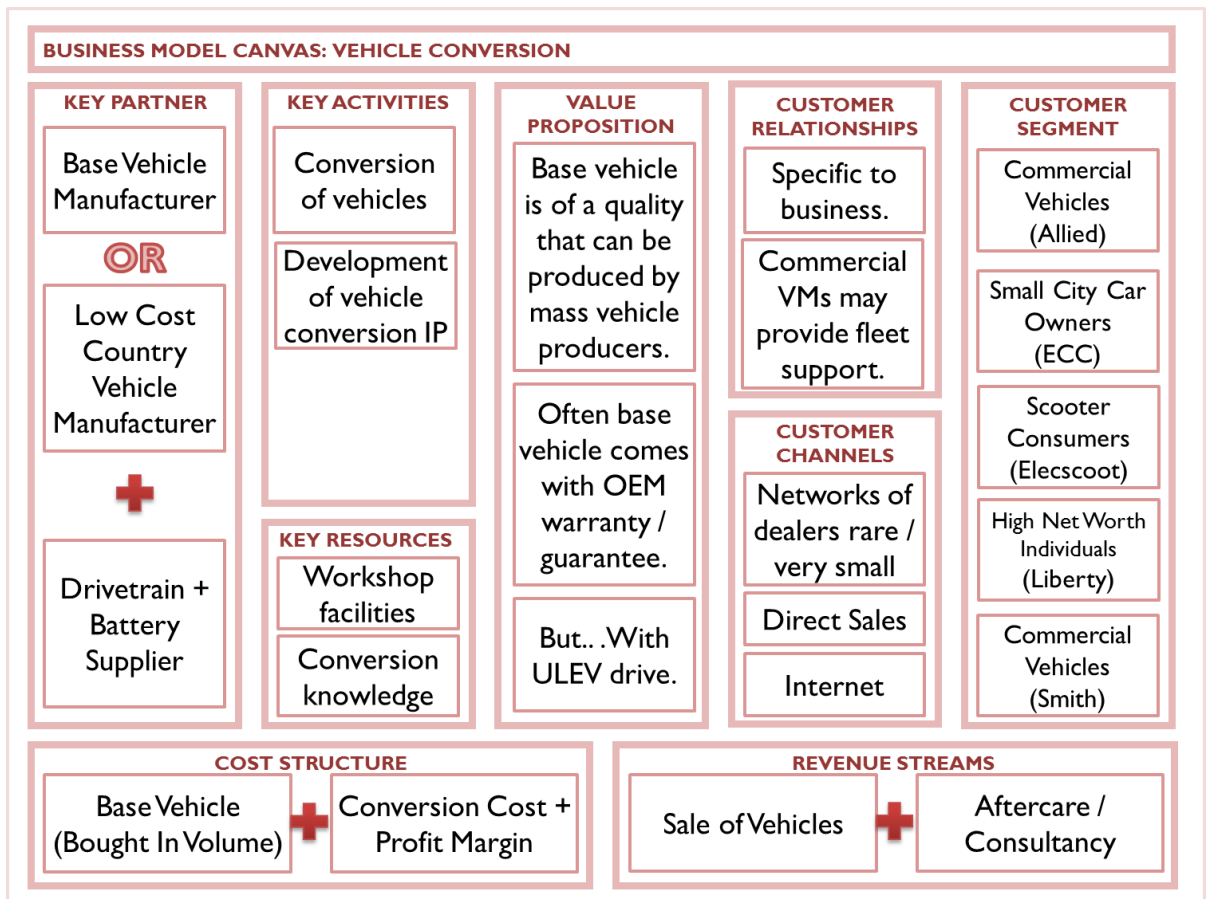
There is a distinct business model in the SME vehicles sector, of taking vehicles that are produced in quantity, and converting them to be ULEVs. Within this business model archetype, two subtypes are identified. The first is taking vehicles from volume vehicle producers which do not offer a ULEV variant and performing a conversion to EV operation, by stripping out the ICE and replacing with an electric motor and batteries. The other, is taking vehicles, usually EVs, that have been produced in a low-cost country such as China, and performing modifications on the vehicle to make them fit for the UK market. This could be modifications to make the vehicles legal on UK roads, or quality modifications, that enhance elements of the vehicle to make them suitable for UK consumers. These are summarized in the table below.

Case Study	Original Base VM	Vehicle Type
<b>Allied Electric Vehicles</b>	Peugeot	Conversions of: Peugeot Bipper (eBipper) Peugeot Partner (ePartner) Peugeot Expert (eExpert) Peugeot Boxer (eBoxer) Peugeot Minibus (eMonarch)
<b>Dragon Electric Vehicles</b>	Wide range of vehicles. Chinese imported vehicles.	Bespoke, one off conversions. Conversion to UK standards.
<b>Elecscoot</b>	Range of imported vehicles from China. Started with scooters, has moved to EVs.	Series conversion of a range of vehicle types, modifying to make road-legal for the UK, ad to meet UK standards.
<b>Electric Car Company</b>	Citroen C1	Series production of C1 ev'ie
<b>Smith Electric Vehicles</b>	Range of commercial vehicles from Ford and	Conversions of: Avia (Edison) Ford Transit (Newton) <i>Now discontinued</i> <i>Transit Connect (Ampere)</i>

**Table 25 – A Range of Firms employing a Vehicle Conversion Business Model**

Overleaf is a business model canvas, which explores the core logic of this particular business model. Will it prove to be durable? As volume manufacturers introduce vehicles that encroach upon these specialist firms product offerings, will they cease to be attractive?

Given at the moment, they can command a premium price as a result of their privileged position in the market place, will the relative value they offer be able to stand alone as manufacturers offer their own OEM products?



**Business Model Canvas 27 – Vehicle Conversion Business Model**

### 8.2.5 ‘New’ Business Models

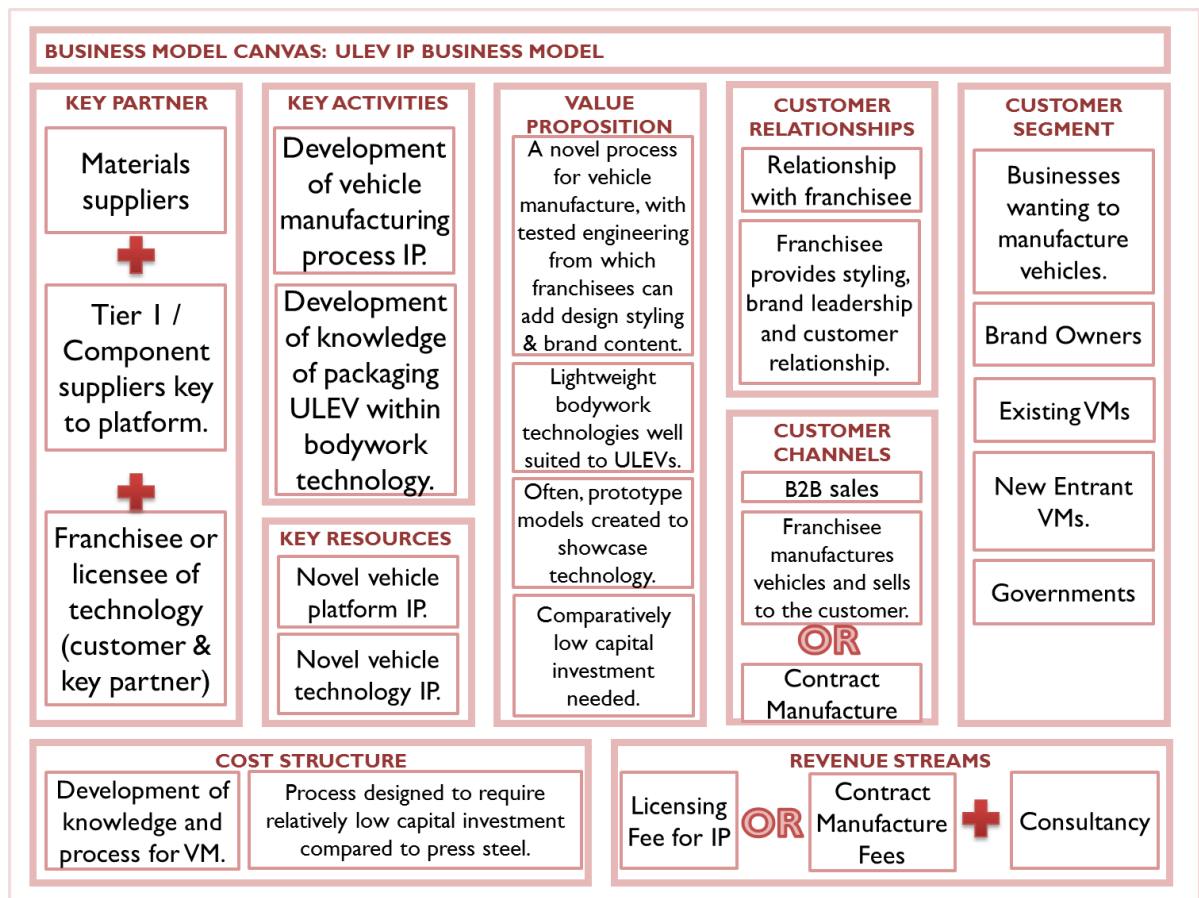
In this next section, a range of “new” business models are considered. These represent alternative ways that firms might engage with the business of car manufacture in non-traditional ways.

The literature review and Chapter 3 addressed the range of business models that could clearly be considered part of the UK Motor Industry; however, ULEVs are creating many opportunities for new businesses to enter the space, and some old ones with new ideas.

In many ways there is nothing ‘new’ about some of these models – Lotus have been exploiting their intellectual property for many years; we can consider Lotus’ involvement with John Z Delorean, undertaking design activities as a historical “IP” business model. So perhaps what is “new” in this respect, is that ULEVs create particular opportunities for certain types of business model to prosper and grow. Some of these business opportunities may be only transient in nature – as when incumbents acquire these capabilities and the transition is underway, the moment will have passed.



### 8.2.5.1 IP Based Business Models



**Business Model Canvas 28 - IP Based Business Model**

This category of Business Models, can be shown to firms whose product, rather than being a vehicle itself, is the licensing of Intellectual Property relating to innovations developed for electric vehicles.

Under this heading, we might consider the licensing of the innovative chassis technology of Axon Automotive by Axontex Ltd (as distinct from Axon Automotive Ltd), the iStream business model of Gordon Murray Design, to license a low capital investment, novel manufacturing process and Lotus licensing of its lightweight chassis technology to a range of manufacturers notably Tesla.

Whilst not developing a specific chassis / bodywork technology, it is clear also, that Liberty Electric Vehicles business model revolves around the creation of novel and innovative IP – and it’s acquisition of Modec adds additional IP and engineering expertise in house. However, this case will be discussed more specifically in the “orchestrator” business models section on p.382.

Why we have isolated these companies as distinct from others who provide ULEV knowledge of IP input, is that they provide knowledge solutions for the manufacture of whole ULEV vehicles. In addition to these “vehicle knowledge manufacturers” we might consider the cases of a range of other embedded cases, that whilst not “vehicle manufacturers” as such, have a similar business model based around the licensing of knowledge related to vehicle electronics and systems integration. Under this banner, we might additionally consider firms like Zytex in the Midlands, AVID and SEVCON in the North East who provide IP based around electric drivetrains.

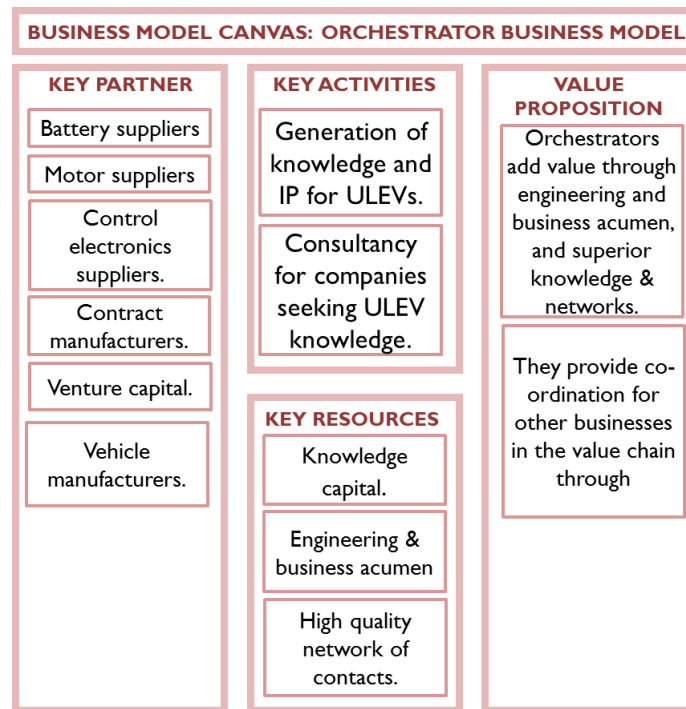
Where those who provide whole-vehicle knowledge differ from the mainstream business model, is that the Key Activities of all of these IP based ventures, revolve around novel chassis / bodywork technology combinations that diverge from the heavy investment required of Press Steel Bodywork.

<b>Company</b>	<b>IP Based Chassis / Bodywork Technology</b>
<i>Axon Automotive</i>	Lightweight chassis technology based on using carbon fibre wrapped around hollow foam cores and vacuum impregnated with resin. Composite plastic panels provide infill bodywork.
<i>Lotus</i>	Lightweight chassis technology based on using aluminium chassis bonded together with high performance adhesives.
<i>Gordon Murray Design</i>	iStream technology based on “iPanels” (lightweight composite panels) for bodywork and “iFrame” (thin walled steel tubes) for chassis.

**Table 26 – Lightweight Chassis / Bodywork Technologies of VMs with IP based BM**

### **8.2.5.2 Orchestrator Business Model**

The “Orchestrator” business model was discussed in the Liberty Electric Vehicles embedded case on page 332. It bears a strong relationship to the IP business model in the previous section; but has distinct and unique attributes. Liberty have also found a unique niche in providing aftercare and support for vehicle models and marques that are no longer supported by their manufactures. This is particularly interesting – where companies that have produced vehicles have ceased to exist; battery technologies have become defunct or are no longer supporter; or manufacturers have abandoned or orphaned EV trial projects, Liberty have found a way to capture the residual value of these vehicles by providing support to their fleet managers and owners. This support involves the development of the support for these legacy products; and developing retrofit solutions that can be used to replace defunct and outmoded technologies.



**Business Model Canvas 29 - Creating Value Through Orchestration**

### 8.2.5.3 Multiple Business Models

In the literature Casadesus-Masanell & Ricart (2010) note that there can be “multiple” business models resident within the same firm. There are also numerous examples throughout the empirical work of “multiple” business models existing within the same firm.

To some degree, can the separate “ULEV” divisions operating within volume VMs be considered as a separate business unit existing within the company? It has been hard to gain precise details about organizational structure in firms – but what is clear, is that some initiatives like BMWi and GM’s EnV concept are developed in “protected spaces” within the same firm.

What is particularly interesting, is observing SME small firms with multiple business models. Despite Lotus relatively small size, it generates revenue through a range of value streams and is agile and responsive to both B2B and B2C opportunities. Here, business opportunities are developed that are synergistic to the firms core competencies of lightweight vehicle structures and advanced vehicle dynamics.

#### **8.2.5.4 Sustainable Business Models**

Whilst there have been a plethora of products examined, with various competing claims about the sustainability of their underpinning drivetrain technologies, there are few “sustainable business models” in evidence. That is to use Wells (2012) definition, “Business Models *for* Sustainability.

Most of the business models in the UK car industry seem to revolve around increased sales of product. Perhaps some of this has to do with the political context of the UK situation – manufactures being encouraged to make, sell and export in order to address the national situation.

The one model that stands out amongst the crowd in this respect is Riversimple. There are many aspects of this envisioned business model that completely turn the logic of the automotive industry on its head. The model has been designed from the ground up to be inherently sustainable, with sustainability attributes, self-reinforcing.

What is challenging here, is that Riversimple is attempting to innovate on two fronts at once, both technical and business model innovation are occurring simultaneously. One of these alone would be a challenge for a new entrant. Perhaps here is a disruptive technology that has the potential to reshape the industry. There is a degree of commonality between some of the ideas in Riversimple, and some of the ideas in the BMWi business model. Perhaps if BMWi gains traction, it will legitimise some of the more radical thinking in the Riversimple model, increasing the chances of the latter in entering the market?

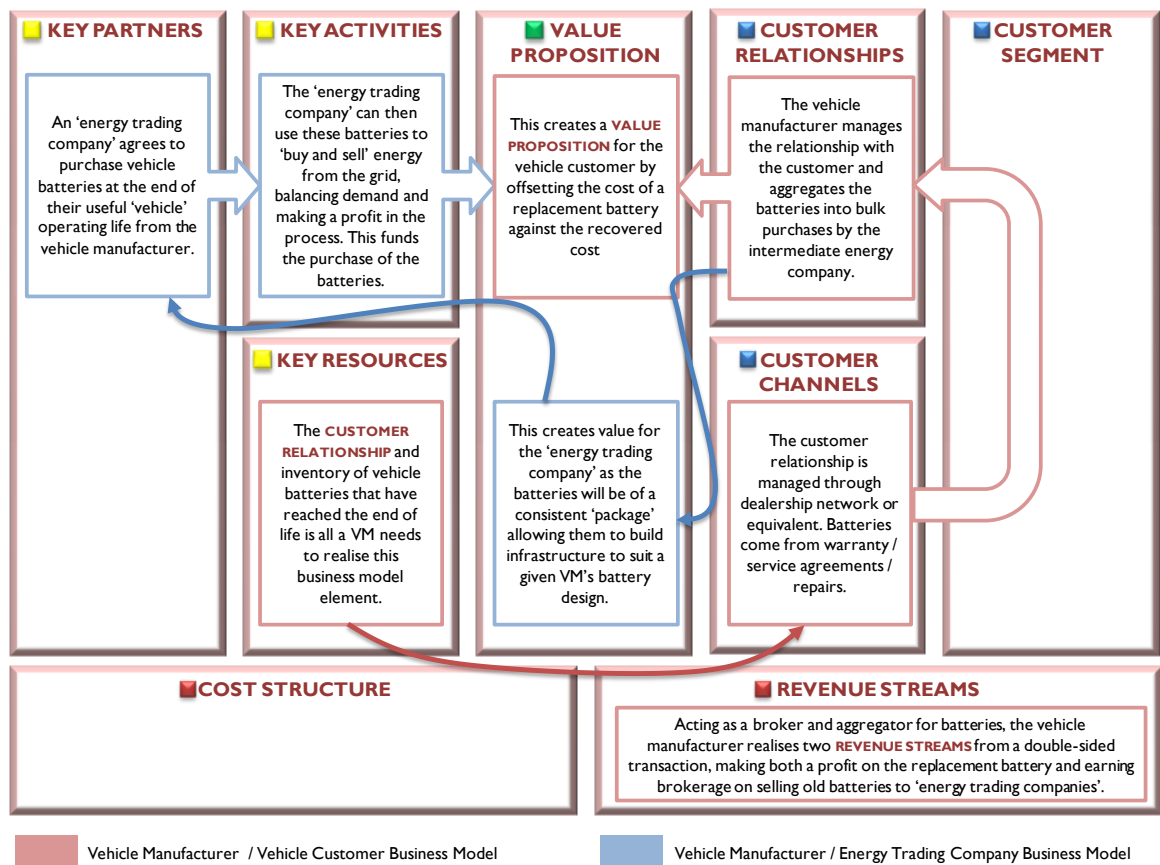
#### **8.2.6 Supporting Ancillary Business Models**

Whilst this thesis has concentrated on the business models of those introducing new ULEVs to the UK marketplace, it is clear that the introduction of large numbers of Ultra Low Emission Vehicles to the UK marketplace is going to create opportunities for new businesses and business models to support the emerging industry. There is an emerging market space for which opportunities exist for outsiders, new entrants and businesses not traditionally aligned with the automotive industry. This next section considers some of the ideas, that have been encountered in the course of this research.

### 8.2.6.1 Second Life Battery / Fuel Cell Business Models

*Just thinking of battery technology, the question is most vehicle manufacturers will buy their batteries externally, so how do you create a value stream there? Do you pass the cost on to the consumer? Do you start separating vehicle ownership from battery ownership, so the consumer buys the vehicle but then leases the battery for example? And thinking in terms of value chains, what happens where the batteries reach the 80% capacity threshold, what's the second life use of the battery going to be? There is potential there for new businesses and companies to step in to profit from that and make a business out of second life batteries? For example, as storage devices. If there is a bulk of batteries, there might be potential for local companies to balance electricity demands.*

Interview with Luca Lytton , RAC Foundation



#### Business Model Canvas 30 - Second Life Battery Double-Sided Business Model

One of the opportunities that becomes apparent with the introduction of large numbers of ULEV's to the roads, is the opportunity to repurpose or recycle used power train components. Battery manufacturers are responsible for batteries at the end of their useful lives. Batteries used in mobility

applications are subject to a range of very demanding requirements. In the case of fuel cells, the valuable nature of the platinum catalysts used within the fuel cell stack represent an opportunity for recovery or reprocessing. There are early indications that power companies may be interested in vehicle batteries for second-life applications in power balancing and demand side management (AWPresenter, 2010).

#### **8.2.6.2 Swapping / Exchange Business Models**

Common to both TNC/MNC vehicle manufacturers and SME vehicle manufacturers, there is a distinct lack of discussion when it comes to “swapping” business models in the UK context. Elsewhere in this thesis, the challenges of this type of enterprise are highlighted.

Other markets enthusiastically embraced this approach with Project Better Place – however, this venture did not prove viable and durable in the long term. Analysing the markets that ventures such as Project Better Place have chosen to target, as an example of the most-discussed contemporary battery-swap business model we may draw the conclusions that there are contextual factors which account for the appetite of these markets to embrace such technologies.

#### **8.2.6.3 Finance Business Models**

Maxton & Wormald, (2004, pp. 231-238) highlight how significant vehicle financing is as a revenue stream for large automakers. They describe how “*Ford and GM [...] had become banks [...] and not very good ones at that*”. In 2002, vehicle finance accounted for half of GM’s profits (Maxton & Wormald, 2004, p. 231) whilst ‘Ford Credit’ accounted for 42% of Ford’s profits in the same year. [Original source states 142%, presumably a typo]

In other aspects of green technology, there has been a niche for innovative finance business models that help meet the capital expenditure of green technology, allowing its cost to be spread over a larger period – even paid back with the energy saved. This is the case with many companies for Solar Photovoltaics, who have offered installation at no cost to the customer, recovering the cost (and more) over the lifetime of the installation by recouping subsidies whilst the customer gets free energy. There is an opportunity here given the cost structure of ULEVs and cost of energy storage.

### 8.3 Business Model Components

*Are there components of business models which can be analysed in a “standalone” manner; elements of business models which we can examine in isolation from the gestalt. If so, what innovative business model features can we identify?*

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#### Research Sub-Question 3

Recently, since the research themes were formulated, Foss & Stieglitz (2014, p.24) have made the point some business model innovations are “modular” whilst others are “architectural”. This in some way in the genesis of an answer to the question above – some business model innovations are architectural, affecting the whole structure of the business model; whilst some are modular.

To take an example, using Nissan as an example; using “gaming” as an innovative way to create new customer relationships by supplying downloadable add-ons for ‘Sim City’ is certainly an innovative component of Nissan’s business model (albeit a very minor one) – but this is a “modular” business model component. It can be added easily to the business model – it does not fundamentally reshape or reconfigure it. By contrast, we could take Hugo Spowers’ ambitious Riversimple Business Model, or in the international context, BMWi’s business model, and consider this as an ‘architectural’ business model innovation – the entire business model is recast and reshaped.

Furthermore, Casadesus-Masanell & Ricart (2010) argue that within a single firm, there can in fact be a “bundle” of business models. A good example here, would be “Lotus”, whilst there is a clear division between the engineering side of the business, which provides consultancy and Lotus cars, even within the Lotus Cars business, we see a B2C car manufacturer, but also B2B contract manufacture, and an IP based business model based on exploiting the knowledge gained about lightweight vehicle design. This further complicates trying to delineate between different business model components, with components may be shared between multiple “internal” business models.

This is potentially a source of rich synergies and additional value streams for firms, if components from one business model can be leveraged to support others within the firm in a way that reinforces and strengthens rather than undermines other internal synergistic business models.

### 8.3.1 Key Partners

One common feature through all of the interviews is that both TNC/MNC VM's and SME VM's have forged strategic relationships with **KEY PARTNERS** to deliver drive train and energy storage components for ULEVs.

Using electric motors in the wheel hubs is a solution that has only been adopted by 'Lighting' for their high performance sports vehicle, and Riversimple for it's Hyrban. This is significant, as it increases the number of motors required per vehicle.

#### 8.3.1.1 Drivetrain / Motor Alliances

Vehicle Manufacturer	Motor / Drivetrain Developer
<b>Aston Martin</b>	(Supplied via. Toyota Strategic Alliance for iQ) New partnership with Daimler Benz
<b>Jaguar Land Rover</b>	AVL, Zytec Automotive, GKN Driveline, Motor Design Limited, Drive System Design, Williams Advanced Engineering, Delta Motosport, Tata Steel
<b>BMW, Mini, Rolls Royce</b>	AC Propulsion
<b>Nissan</b>	Made in-house
<b>Toyota</b>	Tesla (RAV 4EV) In-house (Prius, Auris)
<b>Vauxhall</b>	LG Chem, General Motors

Table 27 - Key Drivetrain / Motor Alliances between TNC/MNC VMs & Drivetrain / Motor Developers

Vehicle Manufacturer	Drivetrain Developer
<b>Allied Electric Vehicles</b>	Ansaldo
<b>Ginetta</b>	Zytek Automotive
<b>Gordon Murray Design</b>	Zytek Automotive (T.27)
<b>Liberty Electric Vehicles</b>	In-house
<b>Lightning</b>	PML Flightlink, MagTech
<b>Lotus</b>	Lotus Engineering, in-house
<b>Modec</b>	Zytek Automtive
<b>Morgan</b>	Zytek Automotive
<b>Smith Electric Vehicles</b>	In-house
<b>Westfield</b>	Yasa Electric Motors

Table 28 - Key Drivetrain / Motor Alliances Between SME VMs & Drivetrain / Motor Developers

Information for Table 28 and Table 28 was compiled from Sparkes (2007), AC Propulsion (2008)



### 8.3.1.2 Energy Storage Alliances

One of the resounding messages to come from all companies interviewed, whether a TNC/MNC or SME VM, is that one of the **KEY PARTNERS**, is with the company that provides power storage capability for ULEVs. Many TNC/MNC vehicle manufacturers have entered into formal alliances with cell manufacturers, summarised below.

Vehicle Manufacturer	Battery Manufacturer
Aston Martin	(Supplied via. Toyota Strategic Alliance)
Jaguar Land Rover	Axeon (South African Developed Defender)
BMW, Mini, Rolls Royce	AC Propulsion supplied Li-Ion
Nissan	Automotive Energy Supply Corporation (Joint Venture with NEC)
Toyota	LG
Vauxhall (GM)	Compact Power (LG)

Table 29 - Key Battery Alliances between TNC/MNC VMs & Battery Manufacturers

Vehicle Manufacturer	Battery Manufacturer
Allied Electric Vehicles	Axeon
Electric Car Corporation	Axeon
Gordon Murray Design	Zytek Automotive
Liberty Electric Vehicles	In-house
Lightning	AltairNano
Lotus	In-house, Zytek Automotive (Lotus Elise) (Lotus manufactured Tesla batteries supplied by Panasonic)
Modec	Axeon
Morgan	Potenza (Morgan Plus E)
Smith Electric Vehicles	Valence, A123 Systems

Table 30 - Key Battery Alliances Between SME VMs & Battery Manufacturers

Information for Table 29 and Table 30 compiled from: (AWPresenter, 2010; Garthwaite, 2009; Yoney, 2009; Engine Technology International, 2010; The Engineer, 2011; Sparkes, Lightning looking to Zap Tesla, 2007; AC Propulsion, 2008)

Vehicle Manufacturer	Partner	Component	Notes
Jaguar	Bladon Jets	Jet Turbine	CX-75 Concept Vehicle.
Riversimple	Horizon (China)	Fuel Cell	

Table 31 - Other ULEV Drivetrain Component Alliances

Given that Batteries as a key factor of the **COST STRUCTURE** of all electric vehicle manufacturers, and given that cost is cited as one of the main barriers to consumer uptake of EV's (See page 221) it seems a particular area of the business model that is crucial to bring into focus.

*We have been working with large numbers of cell sources – fifteen or so different manufacturers. We have found a wide variation in the supply model adopted by different manufacturers. Large OEMs have a lot of vertical integration – tight collaborative arrangements with cell manufacturers, which in some cases are exclusive. This type of relationship is much harder to access for SMEs. SMEs work through other routes, with Far Eastern cell manufacturers. Quality, potentially, is as good as large companies – but consistency is an issue. So, maintaining consistency from suppliers is a challenge for SMEs. A number of companies have spotted this niche, and will “package” cells, and supply to vehicle developers.*

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Interview with Peter Stevenson, University of Glamorgan

*We will work with a number of battery and cell manufacturers, so depending on what the job actually entails, and the volumes required, we would pick a suitable battery manufacturer – but it also depends who our customer is; as if our customer has any specific alliances or preferences then this would also dictate what batteries we use.*

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Interview with Alec Williams , ZYTEK Automotive Ltd.

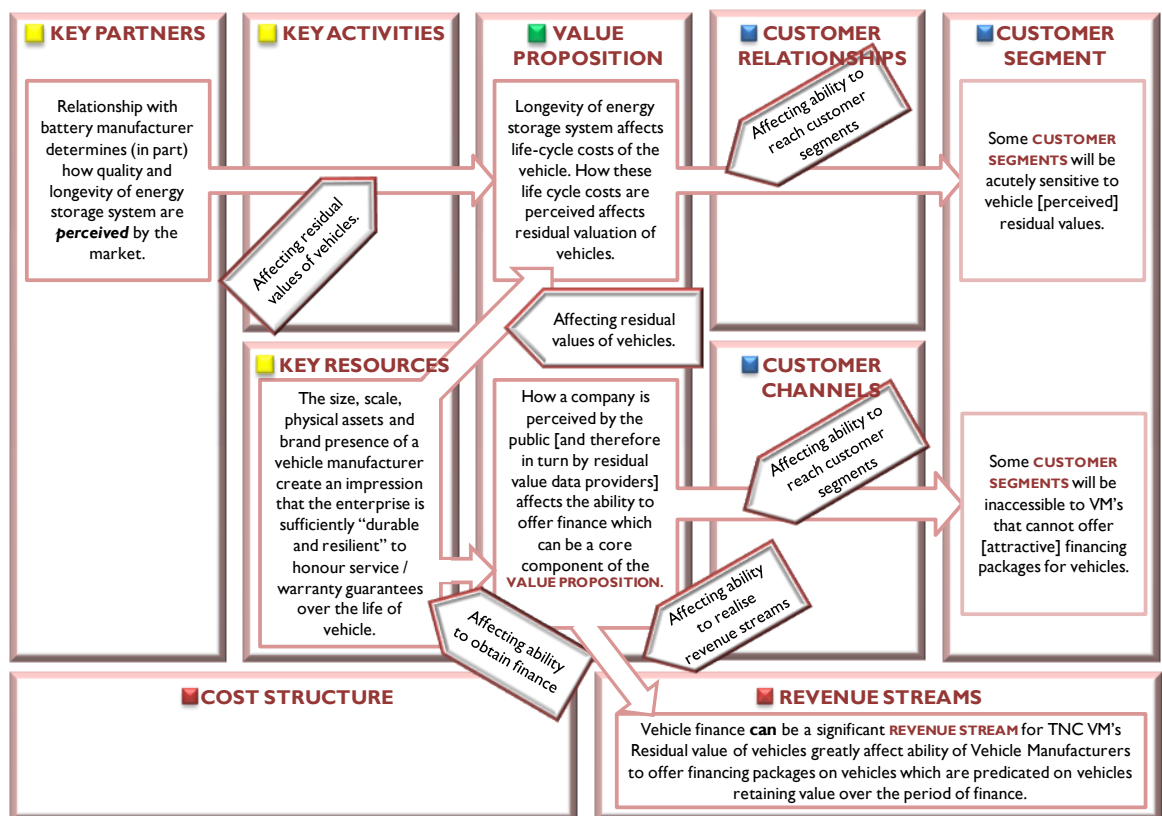
Speaking to the battery manufacturers, it is also apparent that they are actively looking for different alliances, and permutations of alliance to improve their position. In response to the question “Do you have any joint ventures either horizontally (with other battery pack suppliers) or vertically up / down the supply chain?” in an interview with (AWPresenter, 2010) Rebecca Trengrove of Axion answered “There are many things happening in the industry. It is a very fluid industry and it is clear that there is a wide range of types of business model that will be viable.”

One of the challenges, for battery manufacturers, is that battery leasing requires significant capital which is reclaimed over a longer period of time. In an interview with Rebecca Trengrove of Axion, (AWPresenter, 2010), she stated that “Battery Leasing” was not part of Axion’s business model for the reasons stated. However, she intimates that some of their customers – Modec and Allied do offer leasing options on batteries to their customers.

The market for electric vehicle batteries is relatively immature. As the market for electric vehicle batteries has not fully developed, it is hard to predict what new business models may emerge to fill this space. In trying to suggest business models that would fit readily into this problem-space, we need

to look outside the automotive industry. We can see evidence in other sectors, how there is opportunities for intermediate finance companies to serve a role in helping to meet the capital expenditure needs of sustainable investment; recouping the capital – plus a profit – over the lifetime of the technology. These can offer better returns than some financial products – and so investments in sustainable innovation can be “packaged” as alternatives to more traditional financial products. These offer attractive investment opportunities to capital-rich organisations, such as pension funds; who need to provide stable growth over a long period.

Another issue, is that SME VMs are here at a disadvantage compared to TNC VMs as it is harder for them to establish in the mind of the customer the quality of their batteries. This in turn affects the SME value proposition and has manifold impacts for the business model.



**Business Model Canvas 31 -The relationship between ‘Energy Storage Quality Perception’, ‘Residual Vehicles Values’ and ‘Vehicle Financing Options’ shown on the Business Model**

### ***8.3.1.3 ULEV's based on Volume Production Vehicles***

As was seen in the previous section, there are a range of small producers who make vehicles based on another manufacturer's platform. This in turn reduces their Research & Development costs significantly, furthermore, as consumers are already familiar with the vehicle models on which their ULEVs are based.

There are many advantages in commercial terms to working on a new product based on an existing vehicle platform. TNC/MNC vehicle manufacturers ability to buy in bulk, combined with economies of scale derived from sharing parts across vehicles based on the same platform, deliver manifold benefits in the upstream value chain. Their buying power derived from buying in large volumes creates the environment for very favourable exchange conditions for parts, modules and raw materials.

There is also a lower barrier to be crossed in marketing the vehicle to consumers, as conventionally engine variants will be marketed by source companies, and consumers will have familiarity with the basic vehicle.

However, this is counterbalanced by a less technically elegant solution than a purpose-engineered ULEV, where by way of example, weight reduction strategies are even more crucial to vehicle range and performance.

## 8.3.2 Key Activities

### 8.3.2.1 How Key Manufacturing Activities Shape the Business Model

Throughout the entire history of the automotive industry, it can be witnessed that one of the **KEY ACTIVITIES** that adds value to the creation of vehicles is the construction of the vehicle bodywork.

*Volume producers use steel – but of course, because they are using steel, it dictates the volumes at which they have to produce vehicles. So if the large car companies starting producing vehicles out of carbon fibre, aluminium, lightweight technologies – they would still be “large car companies”, but they would not be “volume car producers” – they might offer a larger range of models, say 200 models rather than 20; but these would be produced in much lower numbers.*

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Interview with Prof. Steve Cousins, Axon Automotive

Aluminium is lighter than steel, it retains many of the benefits to industry of working with pressed steel – and even adds some more as was seen in the Jaguar Land Rover case study. It is the material that Tesla have adopted for their model S; and within the UK car industry, there is experience in working with aluminium amongst a range of producers: Aston Martin, Rolls Royce, Jaguar Landrover.

However, perhaps more interestingly, Aluminium is also being adopted as a material of choice by a number of smaller niche producers. Lotus have long used bonded aluminium for their chassis components, showing that Aluminium has utility amongst smaller producers as well. What is also interesting is that new processes and technologies allow aluminium body panels to be formed using smaller scale technologies. Superforming is a process that has been used by both Morgan, and also by Lightning. Superform (2013) provides a detailed description of how the technology can be used.

There is much greater diversity amongst the SME VMs in the bodywork processes used to produce these low volume production vehicles, indeed it is a defining point of business model differentiation that smaller producers do not have access to the large press steel tooling.

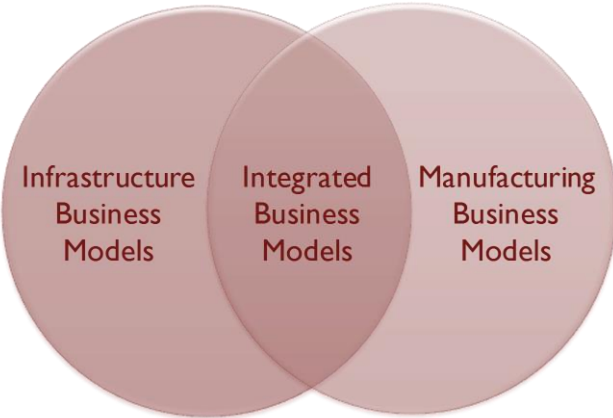
Particularly interesting is the potential of the novel bodywork technologies championed by companies like Axon and Gordon Murray Design. If these can be brought to maturity at suitable cost, they may yet offer a challenge to the mainstream use of steel.

**8.3.2.2 Infrastructure vs. Manufacturing Business Models**

In the case studies examined, almost every TNC/MNC ULEV manufacturer is partnering with a utility or infrastructure provider in some way. In all the cases, this relationship is usually relatively shallow and takes the form of sharing information or engaging in joint marketing activities - the utility providing installation of equipment upon purchase of a vehicle e.t.c. The business operations, and identities of the two companies undertaking infrastructure development and vehicle manufacture are distinct and separate.

Looking globally at initiatives for electric vehicles, it can be seen how initiatives such as 'Project Better Place', to cite the most obvious example attempted to draw operators of the 'vehicle manufacturing' business model, with that of an 'infrastructure' / fuel retailing business model. Ultimately, this venture failed. Whilst the IP relating to the battery swap infrastructure was novel, it wasn't sufficiently engaging to generate significant media interest.

In the future, perhaps there might be other attempts to engage in this hybrid role of manufacturer and infrastructure provider. Perhaps the only evidence of this in the embedded cases is in the example of Riversimple, who if their model comes to fruition, will supply both vehicles and energy as a service to their customers.



**Figure 119 - Infrastructure, Manufacturing & Integrated Business Models**

Osterwalder & Pigneur, (2010) term this type of business model design as a 'multi-sided platform', which they define as a business model that brings together a multitude of different customer groups, which have very distinct identities, yet are interdependent. The distinguishing characteristic of this model is that the platform is only of value when all the different groups of customers are present. The platform itself "creates value by facilitating interactions between the different groups". The obvious 'customer' is the end-user, who purchases mobility as a service from a 'Better Place' type option; Whilst energy providers, and vehicle manufacturers were described by Better Place as 'Partners', they were really 'customers' of Better Place's 'platform'

In this study, the only company whose business model broadly matched this description is Riversimple (See Page 349) in the UK. As we have seen, their unique lightweight vehicle technology enables the use of a small, cost-effective fuel cell; as one of the few companies offering a hydrogen vehicle, the Riversimple approach to deploy hydrogen infrastructure, and sell mobility as a 'service' integrates.

### **8.3.3 Key Resources**

One of the defining features of large manufacturers' business models was the established resources that they could access. In many cases, this meant that ULEV components could be developed and manufactured using in-house expertise. A notable exception to this was with battery and fuel cell technology, for which even VMs needed to look externally. The study of the embedded cases reinforced the literature review that the Key Resources available to volume VMs tended to constrain their thinking in relation to potential business models, as future business models were naturally predicated on their existing assets.

By contrast, the key resources of smaller firms, most often centred on intellectual property. There are a number of small firms that have also been in the marketplace for some time, that have built up brand cachet, that needs to be defended. However, being smaller ventures, the brands were often already associated with unusual vehicles that differed from the mainstream and therefore these brands were more open to experimentation.

### 8.3.4 Value Proposition

There were a wide variety of ULEV value propositions in the cases concerned. Amongst both SME and TNC VMs, there were a range of vehicles, whose technological value propositions differed from production vehicles in the marketplace only to the extent that they had elements of ULEV drivetrain. This could be seen in the cases of volume manufacturers introducing ULEV variants, and also SMEs offering vehicle conversions.

There were also “performance” ULEV vehicles offered by both TNC and SME vehicle manufacturers.

Furthermore, especially amongst niche manufacturers there is a great deal of novelty and variety in the prototypes of vehicles manufacturers have developed for the UK market.

However, the business models examined are almost unanimous in offering this value to consumers in a simple product purchase transaction. What there is not the same evidence of in the UK context, is offering mobility as a service. There are signs internationally that Peugeot and BMW are exploring business models in this direction. Within the embedded case studies, there is Riversimple, which shows an amazing amount of novelty in the construction of its value proposition.

Whilst there remain significant challenges in bringing the Riversimple Business Model to market, there is a great deal of elegance in the way that the model addresses challenges of sustainability. What is unclear at the moment, is what price point this offering will be.

What is particularly interesting, is looking at the US marketplace where there are ZEV mandates in place. Here, these have dictated minimum standards for manufactures to move ULEVs to the marketplace. As a result, those manufacturers who have produced EVs have in many cases offered subsidised or marginal rental rates in order to get consumers to engage with these vehicles. Whilst demand was initially low, reducing the price significantly has resulted in a dramatic uptake, with waiting lists created. It will be a challenge for manufacturers to discover the price elasticity of demand in relation to mobility services.



### 8.3.5 Channels

It can be seen in other sectors, how new-entrants have used different **CUSTOMER CHANNELS** as part of innovative business models, in order to disrupt the sector and rapidly gain market share. Ordanini, Kraemer, & Dedrick (2006, p. 4) draw attention to the example of Dell with its direct sales to business customers; whilst Medion pioneered the discount retailing of computers to home consumers through the mass-market multiples – both of which proved successful strategies in entering the computer marketplace.

We can see with the Electric Car Corporation (See page 318) how a new entrant business without an established dealer network, is using a different sales channel – selling through ‘Best Buy’ as shown in (Figure 100 on Page 320) a mass-market electrical retailer. This has echoes of Medion’s **‘CUSTOMER CHANNELS’** Business Model Components.

Indeed, returning to the examples of Medion and Dell, with recent announcements of profit warnings from more traditional computer retailers, it can be seen how models of customer **CUSTOMER CHANNELS** in an industry, which appear set in stone can rapidly change over the course of several years. Whilst it can be argued that consumer confidence in the market was a contributory factor to the profit warnings announced by retailers (Felsted & Barrett, 2011), it can be seen how such a business model that relies on a distribution architecture which is expensive to maintain is vulnerable to changing market conditions. Indeed, Best Buy itself was not a durable venture in the UK marketplace, and many electrical retailers have since folded.

The one constant across a range of sectors, appears to be that digital media is having a transformative effect on the channels customers use to communicate with brands. Perhaps this has always been important in recent memory, for smaller firms without extensive dealer networks. The established vehicle industry is also taking these channels very seriously. In the embedded cases we can see investments by Jaguar Land Rover in their IBM developed digital technologies, and the car configurators used by MINI and Vauxhall for their Adam being a significant component of these business models.

### 8.3.6 Customer Relationships

One thing that appears clear through both of the case studies, is that digital technology is going to dramatically reshape vehicle manufacturers customer relationships in the years to come. There is plenty of signs that brands are starting to engage with new technologies.

We see in the Nissan case study, the “Nissan Charging Point” made available for free in the “Sim City” game. In the Jaguar case study, there is the massive investment in creating a digital brand experience for customers, that has been realised with IBM as a key partner.

With Vauxhall, and MINI we see internet based user interfaces for the customisation of the Vauxhall ADAM and the MINI offering customers, flexibility, choice and variety enabled by new technologies. Furthermore, it will be interesting to see whether innovations developed for BMW’s new BMWi brand, will also influence the MINI brand - which has been used as a test platform for modelling customer relationships with electric vehicles.

A number of the small niche start-up companies have shown interesting concepts about how the customer relationships in future mobility may appear. However, some of the ventures with the most exciting ideas, do not currently have the capability to realise these visions as they haven’t got a mechanism for bringing their products to the marketplace.

The Ginetta case study is particularly interesting at showing how with careful management of customer relationships, there is potential to create many additional value streams through providing value added services. There is probably limited potential for Ginetta’s specific set of services to transfer into the mainstream (although it provides an interesting template for other niche companies); it will be interesting to see if Ginetta do bring a ULEV to market, how coupled with the variety of championships and competitions offered demand can be “created” for electric motor sport vehicles. Indeed, Westfield with their iRacer could learn a great deal from Ginetta’s business model of nurturing customer relationships through value added services. These all create an environment and culture that encourages repeat business.

### 8.3.7 Customer Segments

It is evident from this survey of companies offering products in the UK that an exhaustive array of customer segments are being targeted by the various vehicles being brought to market. Amongst early adopters, there is an appetite amongst consumers for high-performance zero emission vehicles, which has not yet been fully satiated by existing product offerings – and there appears to be room for this area of the market to grow.

For companies that target specific niches with deep segment differentiation and a product tailored to specific customer demand, it may be found that existing business models serve these enterprises well and in the short to medium term, there may not be a great need for immediate business model innovation as long as the products that are offered continue to meet the needs of those niches.

Where there is a greater need for business model innovation is in companies that aim to cater to the larger non differentiated mass market, evolving lower impact products that appeal to later adopters.

#### Aston Martin vs. Lightning

It is interesting perhaps, to compare the electric vehicle market entry strategies for Aston Martin and Lightning. Both have a product offering that appeals to a narrow 'segment range'

Ritson (2011) argue that the degree of segmentation a company applies in its approach to developing markets affects the level of business complexity directly. They cite Aston Martin as pursuing a "niche strategy with maximum differentiation for one segment" where all business activities are geared towards delivering a product commensurate with the expectations of customers in that segment.

There has been some criticism of Aston Martin's strategy in relation to the introduction of the Cygnet and it remains to be seen whether the luxury re-work provides sufficient product differentiation from the Toyota on which it is based for it not to be viewed as a 'sheep in wolves clothing' by Aston Martin's customers.

### **8.3.7.1 Corporate Consumers**

An interesting observation about companies purchasing ULEVs for use in corporate vehicle fleets (which came from a number of interviewees from Case Study I) was the observation that “the purchase requisition for the ULEV often comes from the ‘Marketing / CSR’ department budget rather than from the ‘Fleet’ budget. This is interesting, and points to corporate motivations for ULEV adoption.

### **8.3.7.2 Taxi Firms**

An interesting customer segment that is interesting to look at is ‘Taxi Firms’. Here, in the UK context, it is interesting to note that one SME vehicle producer, LTI has been a dominant force in the London taxi marketplace. The electric vehicle manufacturer Modec, grew from a project at LTI (See embedded case study page 346). Furthermore, there are other SME vehicle startups that are specifically targeting this niche, specifically Microcab (See embedded case study page 342).

We can see an interesting example of how ULEVs can create value for EV consumers. Here we must delineate carefully between two types of customer segment – the majority of Taxis are owned by their drivers; however, there are also examples of where taxi firms purchase vehicles – which are then leased to drivers. Here we see an example of the old business adage ‘create value for your customer’s customer’ being played out in real life:

In addition to private hire, many minicab firms especially have corporate contracts with taxi firms to deliver their mobility services. Professor Steven Potter notes that in conversations with many minicab firms, they have noted an increase in corporate customers that are making specific requests to their minicab service providers to deliver the mobility services they contract for with ‘low carbon vehicles’. Here, taxi firms purchasing ULEVs can secure competitive advantage over rivals through the purchase of such vehicles, allowing them to reach customer segments which have made a conscious transition from using traditional vehicles. This is the subject of ongoing research at the Open University.

### 8.3.8 Cost Structure

This 'Business Model Component' whilst arguably one of the most critical for success, is one of the most challenging components to interrogate, given the methodology selected.

#### 8.3.8.1 Energy Storage Costs

Many respondents intimated that one of the key costs per vehicle was the cost of batteries or fuel cells that form the powertrain. For this reason, alliances with component suppliers of energy storage systems are universally identified by all respondents as one of the '**KEY PARTNERS**' in their business model. The nature of these alliances is explored more fully on Page

The market for electric vehicle batteries will grow alongside uptake of electric and hybrid-electric ULEVs. (Boston Consulting Group, 2010) predict that by 2020, the market for electric vehicle batteries will be worth \$25 billion ( $\approx$ £16 billion). To put this figure into perspective, Xavier Mosquet of BCG explains *"This burgeoning market will be about triple the size of today's entire lithium-ion-battery market for consumer applications such as laptop computers and cell phones"*.

Reducing the cost of energy storage technologies has been one of the long-standing challenges of the green automotive industry. Rebecca Trengrove of Axion in an interview with (AWPresenter, 2010) states that 60% of the cost of a battery-pack is in the cells alone.

This presents all manufacturers universally with a challenge – the purchase price of vehicles will in large part be determined by the price of energy storage technologies. (Boston Consulting Group, 2010) Massimo Russo, "Even in 2020, consumers will find this price of \$8,000 to \$10,000 ( $\approx$ £5000 to £6400) to be a significant part of the vehicle's overall cost. They will carefully evaluate the cost savings of driving an electric car versus an ICE-based car against the higher up-front cost,"

This is a view supported by current research on the matter by (Brooker, Thonton, & Rugh, 2010) at NREL, who assert that present [2010] electric vehicle batteries have a cost in the region of \$700/kW and (Boston Consulting Group, 2010) who place current battery costs for automotive applications are in the region \$1000-\$1200 /kW ( $\approx$ £640-£765 /kW) – but this needs to drop to \$300/kW ( $\approx$ £190/kW) (Brooker, Thonton, & Rugh, 2010) for electric vehicles to become cost-competitive with petrol

vehicles over an assumed 15 year vehicle lifecycle. (Boston Consulting Group, 2010) assert that the long-range target many vehicle manufacturers are using in their planning exercises for battery electric technology is \$250/kw ( $\approx$ £160/kW).

Of course, appraising costs over a vehicle lifecycle of 15 years, neglects the facts that present average vehicle lifespans are often much shorter. As noted in Chapter 5, there is a continuing trend in the UK of increasing average age of the UK vehicle fleet since first registration (Department for Transport, 2010), and longer lasting more durable vehicles have the potential to be inherently more sustainable if they are zero emission.

As noted by (Wells, 2003) some types of vehicle have inherently longer lifecycles – luxury vehicles and iconic vehicles designs are often kept, maintained and cared for by their owners for much longer than more generic ‘disposable’ vehicles. Furthermore, high-end vehicles *may* employ lightweight bodywork technologies – [aluminium, carbon-fibre e.t.c.] which do not degrade as readily as steel.

Whilst new business models can go some way towards amortising the capital costs of batteries over the lifetime of a vehicle’s use through product-service systems (See page 168) or different battery ownership models – what is clear, is that the purely financial cost of ultra-low emission automobility will inevitably be higher than for conventional vehicles, unless the cost of energy storage technologies can be reduced to the point where lifetime ownership of electric vehicles reaches cost-parity with conventional vehicles. Boston Consulting Group (2010: 9) discuss the challenges of appraising the different TCO’s of conventional vehicles and EV’s (and this same argument would extend to other ULEV technologies). Given uncertainty over things like the price of oil over time, individuals driving patterns and habits e.t.c. there are subjective judgements to be made in a relative appraisal of vehicle TCO. As Massimo Russo author of the BCG report has stated: *“It will be a complex purchase decision involving an evaluation of operating costs, carbon benefits, and potential range limitations, as well as product features.”*

### **8.3.8.2 Cost Structure & Vehicle Weight**

Although not examined quantitatively in this thesis, it would be interesting to compare the cost structure of lightweight materials, vs. the reduction in cost for expensive energy storage components. Light weighting is an approach adopted by many, how does this affect the cost structure?

### 8.3.9 Revenue Streams

Vehicle sales are the most obvious revenue stream, and this dominates many of the business models that have been examined within the empirical study. As noted previously in this section, business model innovation offers the potential to move beyond models of “product sales” that encourage consumption. However, in the UK industry, this potential is as yet unrealised.

That said, there is interesting evidence of a range of revenue streams supporting niche ventures which are worthy of further exploration:

Ginetta is particularly interesting, for the range of value added services it offers consumers of their vehicles. Whilst these services “encourage consumption” of their car and vehicle, and so are not perhaps ‘sustainable’ environmentally, they do help to sustain Ginetta as a small car manufacturer economically.

Furthermore, with Lotus, there is an interesting Revenue Streams through contract manufacture of a range of lightweight vehicles that rely on its aluminium body architecture. The vehicles that have been based on Lotus architecture are also niche vehicles that target narrow customer segments – however, through this line of work, Lotus have also acquired knowledge about EV manufacture.

There are many businesses in the UK that are capitalising upon Intellectual Property generated about ULEVs. It will be interesting to see whether this leadership can be maintained, and whether these revenue streams prove durable as information about electric drivetrains diffuses further into the industry.

What is perhaps most interesting, is the degree to which Tesla in the US, and Nissan (although Leafs are also made in the US) are earning revenue from the sale of ZEV credits to non-compliant vehicle manufacturers. This is having the effect of redistributing revenues between the regime and new niches, and is a policy measure that whilst resisted by many auto manufacturers has clearly encouraged compliant behaviour.

## 8.4 Transition Pathways & Mechanisms

*What pathways for transition can we identify, and how do these relate to the existing literature? Can we identify any new mechanisms of transition, or contribute to the understanding of existing transition pathways.*

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### Research Sub-Question 4

Considering the context in which the cases have been based, there has been no immediate pressures as a result of an external shock to create an ‘*alignment and dealignment*’ or ‘*technological substitution*’ pathway (Geels & Schot, 2007, pp. 408-410), and so in the absence of these very strong landscape pressures, there has been no strong rationale for the regime to move away from its proven business model. That is not to say that if predictions regarding ‘Peak Oil’ are correct, an ‘*alignment and dealignment*’ may not occur in future; it is not beyond the realms of possibility to imagine an event of a scale similar or greater to the oil-shocks of the 1970’s catalysing either a greater alignment and dealignment of the existing regime, or greater substitution of niche technologies, however that has not yet happened and was not observed in the period under observation.

If anything, a political swing to the right in the UK, combined with a slow fragile recovery, have served to stifle innovation by discouraging any significant regulation or interference with the entrenched regime who are tasked with the process of generating economic growth and rebalancing.

In truth, whilst niches have gained pace, no transition has occurred in the timescale examined and so it is challenging to make any meaningful contribution to this research theme. This is a disappointment, however, in some ways it has been compensated for by the contribution of theoretical linkages between the transitions and business model fields of scholarship.

In Geels & Schot’s (2007, p. 406) ‘*transformation*’ pathway, moderate landscape pressures, combined with immature niches results in slow adaptation by the regime, however, the niches are not able to capitalise on the landscape pressures because of their relative immaturity. There is some evidence for this within the cases. One of the major barriers to entry for some of the smaller niche competitors is that support mechanisms are geared to “Class M1” vehicles. As such, manufacturers must meet certain standards in terms of quality and safety, which require a stringent testing regime. This is a



significant barrier to entry. Note that one of the early niches in the UK was quadricycle vehicles, such as the G-Wiz growing in popularity in London, in order to circumvent the congestion charge.

#### **8.4.1 “Compromise” Products as a Transition Stepping Stone**

In the transitions literature, there are examples of products that represent stepping stones in the process of transition. These products are compromises between the old regimes, whilst exhibiting signs of the new regime. As the new regime gathers momentum, there eventually becomes less need for these compromise products, and they are replaced by products that are fitted to the new regime.

From the cases examined, there is a clear evidence of this taking place. We can see products that are wholly of the ‘new regime’. Amongst volume manufacturers, the Nissan Leaf is perhaps the most ambitious product on the UK market at the moment, being a pure ‘EV’. Whilst some would argue that with ‘pressed steel’ bodywork, there were potentially more optimised products (lightweight, carbon fibre BMWi), the Leaf is significant as it is an electric vehicle that has been engineered from the ground up to be an electric vehicle.

Compromise products in this case, might be existing vehicles that whilst not designed to be electric vehicles, have been re-engineered to accommodate electric drivetrains. Here we might consider firms such as Allied Electric Vehicles, Smiths Electric Vehicles and the Electric Car Company, all of whom have re-engineered mainstream vehicles with electric drivetrains. We might also consider vehicles like the Vauxhall Ampera, or “range extended” EV’s to be compromise vehicles, as their “all electric” mileage is relatively low, and range-extenders add additional weight. In time, as the transition proceeds, these intermediate products may have less relevance in the marketplace once a larger penetration of ULEVs is achieved. This will be a significant challenge to the business models of some of the smaller firms, whose business models are reliant upon the lack of product offering from larger manufacturers.

How will these business models evolve in time? There is an interesting question about how ‘business model evolution’ and ‘change models’ accompany technological transition. In this thesis, there has not been enough of the transition observed to make any concrete observations.

## 8.4.2 Prototype Vehicles as a Tool for Business Modelling

One thread that was consistent across both TNC/MNC and SME manufacturers; is that in some instances, prototype vehicles have been constructed as part of the process of business modelling. In a new market, where demand is uncertain, prototype vehicles form a focal point for discussion – helping to make the capabilities of manufacturers known to both customers and policy makers. This was especially well captured – and made explicit - by an extract from the following display inside the MINI E at the Low Carbon Vehicles 2011 event organised by CENEX.



**Figure 120 - Display Literature inside MINI E at LCV 2011 Event (pictured in Figure 87, Page 272)**

The quote, immediately below the tagline '100% MINI, 100% ELECTRIC' is reproduced below.

***The MINI E is a development vehicle, informing future market products, infrastructure, policy-making and business modelling.***

**Quote from Display Literature inside MINI E**

This is significant; it shows the role of prototype vehicles in not only engineering and process testing and of gauging customer feedback – but also in the process of modelling the business fundamentals

themselves. Whilst this is an approach that is being used by some of the larger VMs, it is also being used extensively by smaller SME VMs. In some cases, prototype vehicles provide a way of demonstrating the capabilities of new technologies – as in the case of Axon Gordon Murray Design and Riversimple.

In other cases, prototype vehicles are used to try and model how SME manufacturers whose BM is ICE focused might transition to alternatives – this is the case with Ginetta, Morgan and Westfield.

What this prototyping and testing of vehicles perhaps evidences, is that there is some understanding that there is a need for ‘reconfiguration’ of the industry, but there is not at the moment a complete understanding of the nature of technological substitution that will take place, nor of consumer readiness for these new technologies. The testing and modelling processes allow these new models to be tried in a low-risk way.

### **8.4.3 Orchestrators Acquiring Capabilities**

The Liberty Electric Vehicles embedded case is interesting, because it shows a potential transition mechanism that has been identified; firms with “orchestrator” business models acquiring capabilities through the acquisition of other firms. This can be considered a form of niche Agglomeration – niches not being subsumed by larger companies – but smaller, ‘challenger’ companies agglomerating to larger ones to form larger concerns. At the moment, this is still a small niche company, but if this pattern were to repeat, the firm would likely grow. The Orchestrator Business Model has already been discussed in section 8.2.5. For this section, we are interested in transition mechanisms. In other sectors, we have seen the growth of companies that had once acted as “orchestrators” within the value chain, grow and build sizeable brand presences (the case of Medion is used in the I.T. industry). Are these ‘orchestrators’ in a key position to organise the agglomeration of niche interests into larger entities with the potential to challenge the regime?

## 8.5 Incumbent vs. Insurgent Business Models

*What is the relationship between ‘Incumbent’ and ‘Insurgent’ firms? If the Insurgent firm’s business models are more radical and different than the traditional industry, how do these ideas transition to the marketplace?*

### Research Sub-Question 5

One of the themes of this thesis is the juxtaposition of large volume TNC/MNC vehicle manufacturers, against smaller SME VMs. Competition on the grounds of cost becomes near impossible, as SME VMs cannot hope to attain the economies of scale easily reached by large manufacturers – so SME VMs must differentiate their offering in different ways. In order to survive in competitive marketplaces, SME product producers in markets dominated by TNC/MNC producers must differentiate their product sufficiently in order to attain a price premium from producers to justify the dis-economies of scale that come with low-volume production.

### 8.5.1 Contrasting Regime & Niche Business Models

	<b>Regime</b>	<b>Niche</b>
<i>Key Partners</i>	Firms within the regime have access to high quality relationships with other large Tier 1’s within the regime. Have the presence to establish JV’s with companies outside of vehicle industry, e.g. batter tech.	Smaller firms do not have the presence in the marketplace to establish the same quality of relationships with Tier 1’s. Some however, have established relationships with OEM VMs to which they “add value” to vehicles.
<i>Key Activities</i>	Firms within the regime are wedded to processes which necessitate high volumes which dictate other elements of the business model. (Press steel)	Niche firms use a much wider range of activities to produce vehicle bodywork. Often these are more labour intensive but can yield lighter weight bodywork.
<i>Key Resources</i>	Large existing investments in press tooling, ICE manufacturer. An asset but also a barrier to innovation.	Often undercapitalised, resources are often IP rather than physical. New ideas, processes, methods or business models.
<i>Value Proposition</i>	A range of different drivetrain technologies are being trialled and there is variety in the types of vehicles being deployed. There is however less variety in the bodywork technologies used.	Also a range of different drivetrain technologies.
<i>Customer Relationships</i>	Established brands which customers may already have a relationship with. This ‘brand expectation’ shapes to some degree the sort of products firms are willing to offer.	Smaller SME firms may not have the established relationship with customers, allowing them to be creative with their product offerings and to offer ‘radical’ products that are potentially disruptive.

<i>Customer Channels</i>	Relationships managed through large, established dealer networks. Customer's expectations of the 'brand promise' shape the sort of vehicles being produced by these brands.	Firms will not have the same large established dealer networks that larger firms have access to. Niche products sold based on "reputation". Some brands (Lotus, Morgan) have built up a respected historical pedigree, despite being smaller firms. Harder for 'mass market' SME's to enter the market with no track record.
<i>Customer Segments</i>	TNC/MNC firms have the size, scale and scope to target multiple customers segments with a very differentiated product offering. Flexible manufacturing brings the potential to target smaller niches. This may encroach on the niches of smaller producers.	Many SME firms are targeting specific niches – e.g. Sport, specialist, commercial vehicles e.t.c. The harder proposition is those smaller firms who are trying to introduce a "mass market" product.
<i>Cost Structure</i>	TNC/MNC vehicle producers rely on large scale for cost economies. Pressed steel bodywork is one of the key processes used in bodywork production, and this activity dictates the scale on which TNC/MNE business models must operated. Common to both cases is the high cost of energy storage technologies. TNC's likely to have a direct alliance with a battery manufacturer.	SME firms are reliant on bodywork / chassis processes that are more labour intensive than pressed steel bodywork. Producing vehicles on a smaller scale carries greater overheads than volume production. So most firms carefully target niches where they can add value that large firms cannot. Common to both cases is the high cost of energy storage technologies. SME's may use intermediate firms like Axion to provide Quality Assurance of battery technologies.
<i>Revenue Streams</i>	The industry's business model is still configured around revenue from sales of vehicles. Finance may also be a significant revenue stream for large VMs.	SME vehicle manufacturers reliant on sales of vehicles for revenue. Small firm's do not have access to the same 'finance' options as larger firms, and therefore must be more reliant on wealthier consumers. Some evidence of innovative generation of revenue streams e.g./ Ginetta selling an 'experience' rather than just a vehicle.

### 8.5.2 Characterising Competitive Forces Between TNC/MNC & SME VMs

One theme to emerge, is how TNC/MNC VMs, are encroaching on the territory of SME VMs, through the development of niche and specialist products which appeal to **CUSTOMER SEGMENTS** traditionally served by low-volume specialist manufacturers. This is captured by the following interview extract:

*They can produce a vehicle that they have spent millions of pounds to develop, for a price – because they have the volume – that competes with our product – which we haven't spent millions of pounds developing. Clearly then as a VALUE PROPOSITION, you have to differentiate yourself by some other means.*

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**Paul Faithfull, Westfield Sportscars Ltd. / Potenza Technology Ltd.**

This is in part due to increased flexibility of mass-production processes employed by TNC/MNC VMs which now enable tooling to be rapidly reconfigured to produce different vehicles on the same line in a much shorter space of time. We see in the Vauxhall case study, how the Adam (which was considered as a potential EV platform) allows for a great deal of purchaser customisation. In business model terms, this can be characterised as part of continual evolution of the way **KEY ACTIVITIES** are carried out in the TNC/MNC VM business model.

So if TNC/MNC manufacturers are able to add a greater degree of customisation and target smaller niches through flexible manufacturing, how can smaller firms continue to compete?

*One of [the] key means [by which we differentiate our VALUE PROPOSITION from volume car makers] is weight – we have put a lot of effort into differentiating ourselves by weight – and I don't believe that a large volume manufacturer can reach a weight of less than 700 kilos on a conventional car [because of pressed steel] They have to meet elements of legislation, and the demands of their marketing departments in terms of noise, vibration and harshness, that we don't.*

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**Paul Faithfull, Westfield / Potenza**

A number of the smaller case studies advance lighter weight vehicle chassis / bodywork combinations as a key point of differentiation. Additionally, many of the cases, Axon, Riversimple and Gordon Murray are coming to the market with 'smaller' vehicles than the mainstream industry would consider.

Aside from those smaller firms targeting the mass market, there remain an array of firms who manage to create value through other means – those who add value to mainstream vehicles through adding EV is another business model, but as noted, one that could be vulnerable as large manufacturers attain capabilities.

Aside from smaller SME firms, other business models are affected by the flexibility that volume manufacturers are achieving. This has also eroded the value added by contract manufacturers; and can possibly account for a decline in their fortunes across the industry. This business models has been challenged, as the B2B **VALUE PROPOSITION** of carrying out specialist work has now become less relevant, as TNC/MNC VMs bring component and module manufacturers, within their own factory as part of a flexible configuration of **KEY ACTIVITIES**.

That said, CM's may potentially fight back; Arruñada & Vázquez (2006) note that in some other sectors, CM's having acquired the confidence that they can manufacture a product, have sought to establish brand identities of their own – and launch products, which then challenge those of the client they work for. In its extremest form, we can see the example of IBM and Lenovo; where the PC manufacturing arm of a global 'megabrand' was ultimately taken over by its contract manufacturer.

Whilst we have not witnessed this sort of behaviour in the UK ULEV arena; there are some interesting observations from around the world.

*When Vauxhall / Opel was under consideration for sale by GM, Magna – a parts manufacturer, who also contract manufacture vehicles through their Magna Steyr arm were a serious contender*

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(Webb, 2009).

### 8.5.3 Positioning in the Value Chain

(Timmers, 1998) makes the case for examining the role of the firm in the value chain by way of understanding how the firm's business model relates to others in the value chain.

*A systematic approach to identifying architectures for business models can be based on value chain de-construction and re-construction, that is identifying value chain elements, and identifying possible ways of integrating information along the chain.*

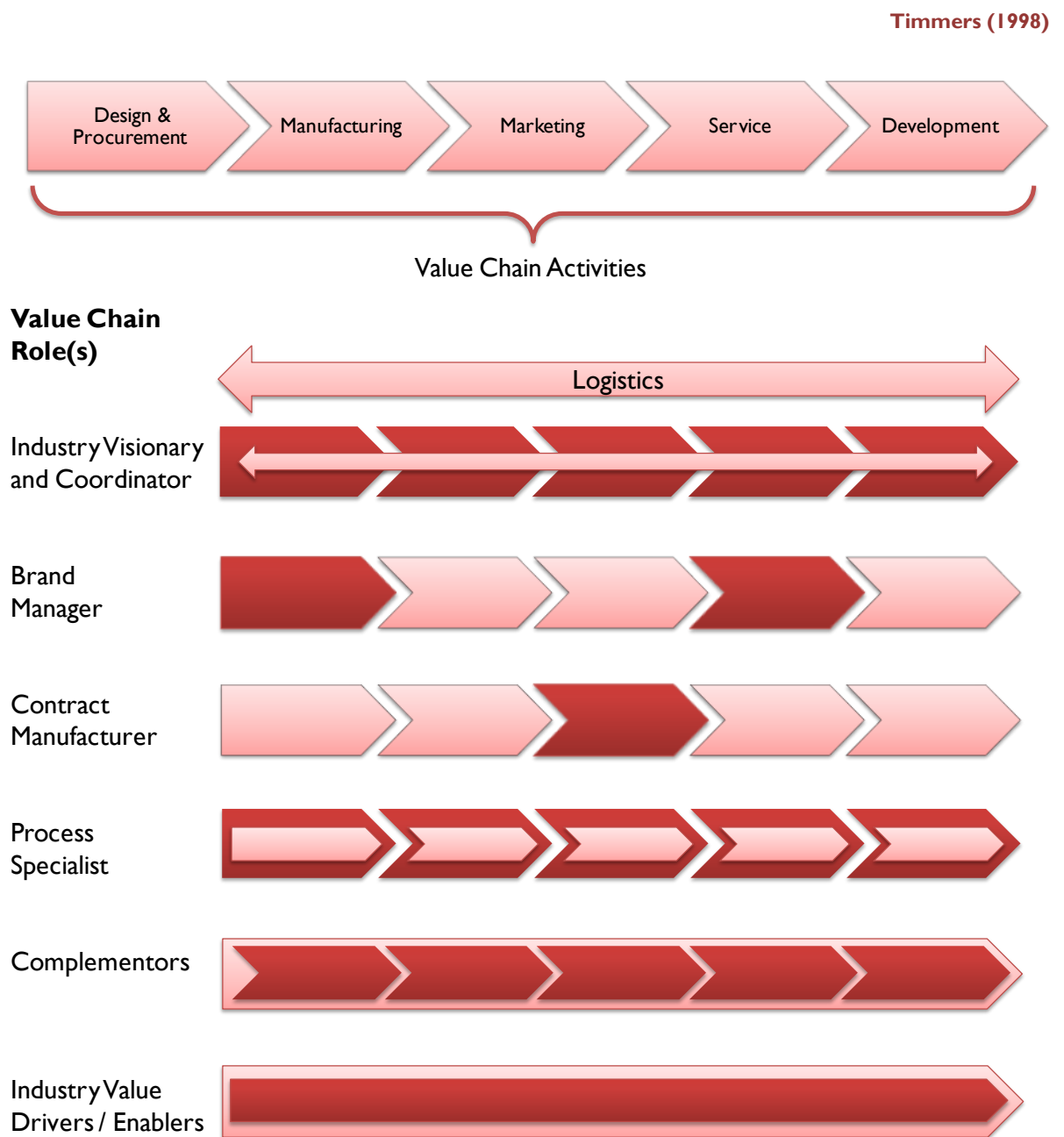


Figure 121 - Positioning in the Value Chain adapted from (Walters & Newton, 2010, p. 3)



Within the SME case studies, we see some interesting cases of firm's that are interacting with the value chain in different ways. Take Liberty Electric Vehicles as an example; their business model revolves around leveraging their intellectual property. Through working with contract manufacturers, and acting as system integrators, they are contributing to the value chain in a 'co-ordination' / 'complementary' manner. Here value is added through intellectual property – and this can be seen in some of the other cases, such as Axon, who have a novel process for their Axontex structural members, which they are attempting to market.

***It might be that smaller companies sell their IP, in terms of business models and technology. I think there is a chance for smaller companies to become more established because of their unique selling propositions, because of what they can offer. In terms of the dynamics of larger companies buying smaller companies, I'm not in a position to say but I can see it happening. For example, Gordon Murray (T25), developed a highly efficient concept car, and is approaching larger manufacturers to see who is interested in both the vehicle itself and the production process.***

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Interview with , RAC Foundation

Furthermore, take the example of Gordon Murray Design, with their iStream process; but looking for partners to franchise the manufacturing system, they might be considered a 'process specialist' which complements a business model such as Yamaha's (Licensee of the iStream process), which perhaps in the respect of their interaction with GMD is acting in the role of 'brand manager' for the Yamaha brand, but with a product offering based on GMD technology.

Luca Lytton speaks to the potentially disruptive effect of these new entrants, the GMD / Yamaha tie up provides a good example that illustrates the point.

***I think it will require established manufacturers to rethink their current business model and the way they sell their current products. At the moment, that can be an inert process, because large companies might move slower than smaller companies because they can be viewed as locked in to their standard operating procedures in the way they do things. There may be opportunity for smaller niche manufactures to step in to provide radically different technologies but also ways of offering their products.***

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Interview with Luca Lytton, RAC Foundation

### 8.5.4. Niches: Knowledge Based Business Models

The competitive advantage of the niche business model, if it does not come from resources, comes from knowledge and ideas that can be used to challenge the mainstream industry. We can also see how knowledge transfer collaborations have catalysed a number of concept vehicles.

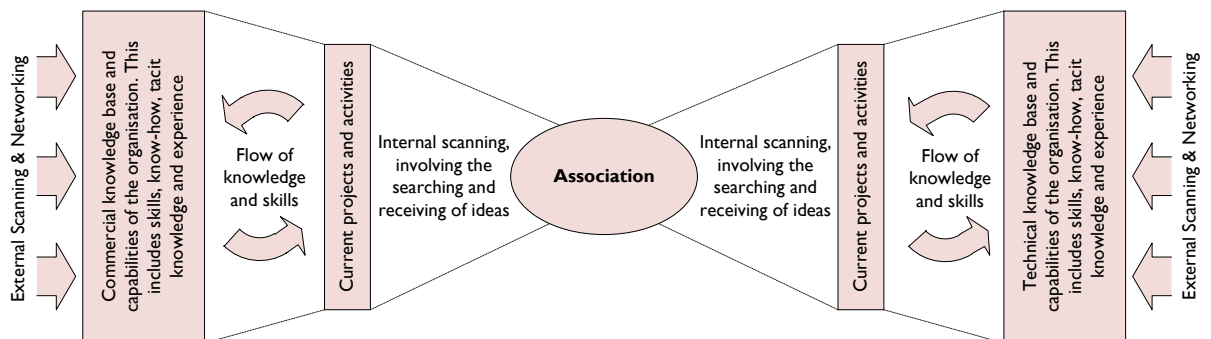
In the case of many of the SME VMs, the driving force behind business model strategy is the entrepreneurial vision of firm founders. This is often augmented with ‘knowledge transfer’ from previous projects of endeavors – as shown in the following table:

Firm	Knowledge Transfer
<b>Axon Automotive</b>	Prof. Steve Cousins previous academic work on lightweight composites in the automotive industry influenced the design of Axon’s unique bodywork system.
<b>Gordon Murray Design Lightning</b>	Gordon Murray’s extensive experience in the automotive industry, designing vehicles for Formula 1, Brabham & McLaren, Midas cars. Lightning GT based on a completely radically re-engineered version of the Ronart Lightning Kit Car, designed by Arthur Wolstenholme in 1999. Ronart was set up by Wolstenholme in 1984 and developed the Alicat aluminium bodied Jaguar racing car, and the W152.
<b>Modec</b>	An academic project by Jevon Thurston-Thorpe evaluated possible future business areas for LTI. Out of this project, and LTI came the spin-off Modec.
<b>Riversimple</b>	Hugo Spowers’ previous work on the Morgan LIFEcar, and involvement in the motorsport industry

Table 32 - How SME VMs current BMs are influenced by ‘knowledge transfer’ from previous ventures.

Table 32 - compiled with additional information from: (Ronart Cars, 2008)

This resonates with an area of the technology transfer literature that focuses on creating business opportunities by association, which is based on opportunism and networks. The key to effective strategy is working out, given constraints, what activities energy is best directed at.



Source: Trott (2002)

Figure 122 - Creating Business Opportunities By Association

### 8.5.5 Technological Learning Curves

One of Kemp's (1994, p. 1028) explanations for the durability of technological regimes is the concept of the learning curve: unit labour input per unit of output falls over time as experience is acquired. The dominant technological paradigm within vehicle manufacture has been refined, such that the cost of producing conventional vehicles is now relatively stable. By contrast, the challenge of developing ULEVs is new to both incumbents and insurgents alike.

Here is a hypothesis, resulting from the contrasting business models of incumbents and insurgents. At the very beginning of the transition, both established businesses and potential challenger businesses are producing ULEVs in such low quantity that they playing field is relatively level. Both companies require a disproportionately high labour input (compared to traditional vehicles) to realise prototypes with unfamiliar technologies. Insurgents – whose [to generalise] business models require a greater labour input per vehicle (by virtue of the more laborious **KEY ACTIVITIES** used to manufacture bodywork), are at a relative advantage at this early point in the technological transition, as prototypes from TNC/MNC volume manufacturers are unusually labour intensive for them to manufacture as they grapple with not only unfamiliar technologies, but body production technologies that are intrinsically geared towards high volumes of production.

That said, when the transition is underway, the early advantage of the incumbents falls away rapidly. The enhanced production volumes necessitated by volume manufacture mean that the incumbents acquire knowledge much more quickly than insurgents. For sure, there will be diffusion of knowledge between the two – schemes in the regime (TSB funding, NVN funding etc.) may even encourage the flow of knowledge between the two. However, the incumbents by virtue of their lower volumes of production, will tend to “learn” more slowly. As a result, labour input per vehicle will also fall more slowly. Furthermore, the fall in labour content of insurgents vehicles [here characterised as using body production technologies that are lightweight, but labour intensive] is ultimately constrained by the labour intensive bodywork processes. This is illustrated in the top section of Figure 123

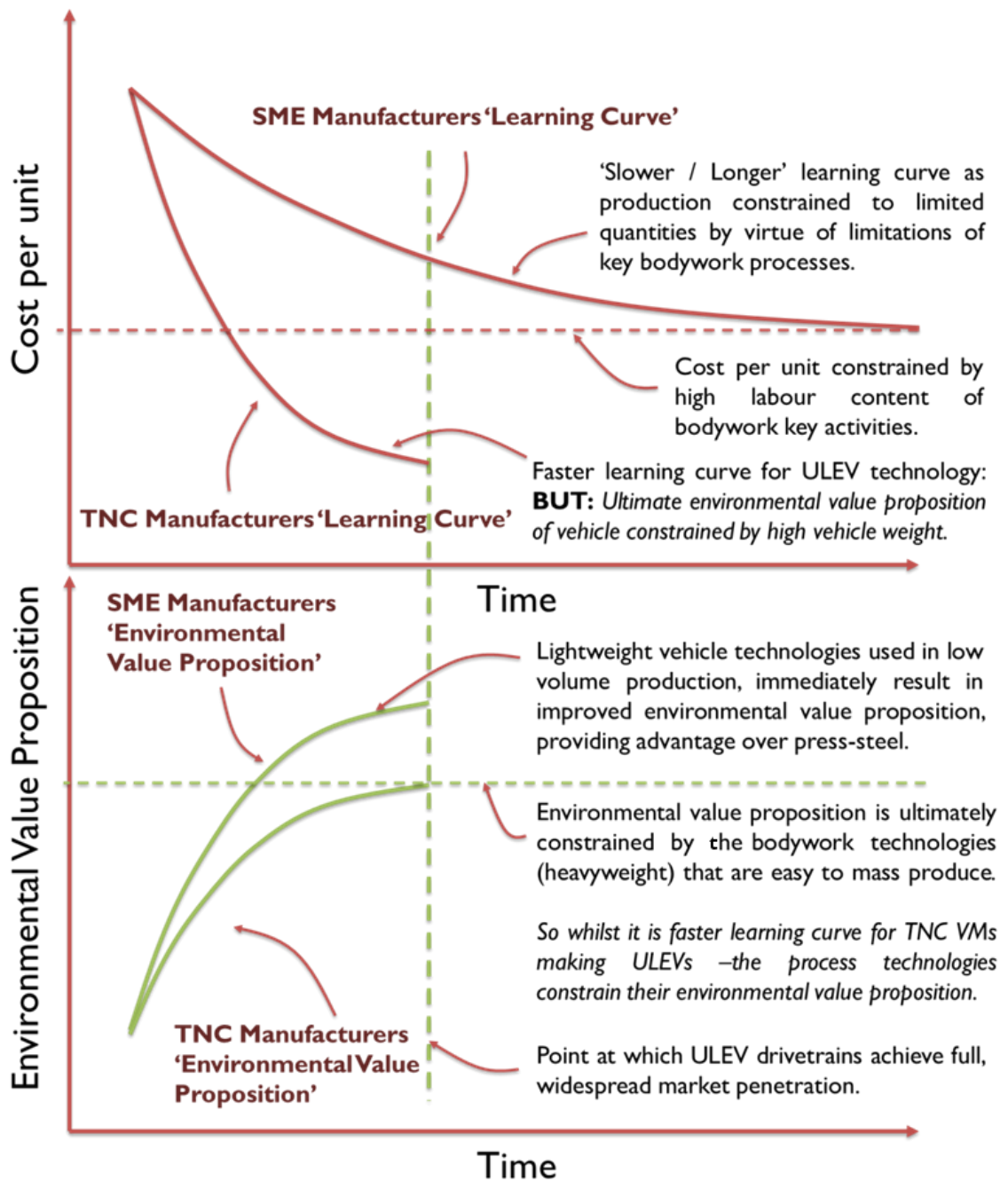


Figure 123 - Learning Curves vs. Environmental Value Proposition

However, there is a flip-side to this. If we characterise TNC/MNC manufacturers as producing vehicles based on, in the main sheet-metal bodywork and ‘heavyweight’ body technologies, whilst SME manufacturers we class as producing vehicles based on ‘lightweight’ composite body technologies; then the environmental value propositions will differ. Whilst as both move to improve ULEV drivetrains, both will improve; the heavyweight vehicles environmental performance is ultimately constrained by weight. Society may accept this, but as Kemp (1994, p. 1031) makes the point, “where there are increasing returns with adoption, it becomes entirely possible that society becomes locked-in to a suboptimal technology”

## 8.6 Design: Product, Process & Business Model

*If ‘Business Models’, ‘Vehicles (as innovative niche products)’ and ‘Vehicle Processes’ are all consciously designed, in what order are these processes undertaken? How can this inform our understanding of the process of innovation? What can this tell us about niche actor behaviour?*

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### Research Sub-Question 5

The tangible nature of products makes it easier to appreciate them as a “designed artefact”. From an engineering perspective, it is also plain that the “productionisation” of products requires the consideration of the processes designed to result in their manufacture. The literature review and some of the cases, consider the potential for the business model to be consciously “designed”. Analogous to the way that a product or process might be designed, even though the business model represents something more abstract.

The goal of this research theme was to explore the interaction between these three conscious design processes. Relating the processes of designing the vehicle, process and business model. The extant literature considers how the business model mediates between “technical” and “economic” domains, however, what is not considered is how the “technical” domain can be further considered as both “product” technology and “process” technology.

When the above question was formulated, in respect of the mainstream motor industry, the researcher felt it was, to a degree, a rhetorical question. It was presupposed that variety would come only from the embedded cases of smaller firms. In the time the cases have been collated, whilst there is still a large degree of homogeneity within those large manufacturers operating within the UK, the BMWi business model in Germany evidences that there are large manufacturers globally that are prepared to radically reconsider not only the product – but also the processes and business models that lead to delivery of the product. This model was considered in Chapter 3, however, as far as this research is concerned, the focus must remain on the UK cases.

To answer this question fully consider the link between ULEV product design, the designed processes that produce ULEVs and the business models creating and realising value from vehicle production.

### **8.6.1 What came first: the product / process design, or the business model?**

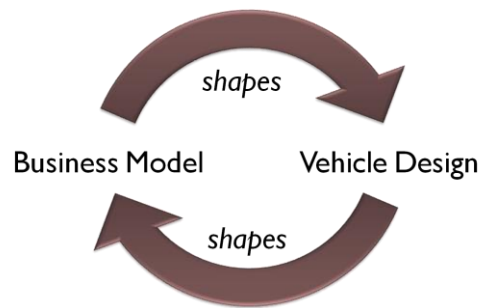
In the literature review, it was considered how our understanding of the innovation literature has evolved over time from linear conceptualisation of the innovation process to richer, more interlinked understandings. Whilst linear models of innovation are overly simplistic, the simple metaphors of “technology push” and “consumer pull” are seductive in their simplicity compared to more complicated later generations of innovation model. To develop the theory in relation to this research theme, to begin with, simple linear models are used. They do not capture the complexity of the situation – but are easy to work with and understand from the perspective of theory development.

Returning to the shortcomings noted in the literature review, Foss, & Stieglitz (2014) note the dearth of scholarship on leadership in business model innovation within established firms. Meertens, Starreveld, Iacob, & Nieuwenhuis (2013) have recently made a significant contribution to this area, by considering the way that business model decisions are taken within firms. Their business case method, provides a consideration of an objective methodology for considering potential alternative business cases in the sphere of “strategy innovation”, “business model innovation” and “product / process” Innovation, which in many ways fits with the context of this next section.

Here, slightly different labels have been adopted. Meertens, Starreveld, Iacob, & Nieuwenhuis (2013) conflate “product and process” innovation, but retain business models and strategy as different contexts.

The distinction between Meertens, Starreveld, Iacob, & Nieuwenhuis (2013) and this section, is that whilst they attempt to propose a methodology of how business models can be compared, and business model decisions reached, there is a more fundamental question of how the decisions of business model, product and process are taken and in what sequence. One of the observations from this research, is that to varying degrees, vehicle- (or to make a more general point product -) design co-shapes the business model. This is represented in Figure 124.

In this diagram, the arrows are of equal size, giving the impression of balance; however the research uncovers differences between the different embedded cases; in some an existing firm with a well-defined business model wants to introduce a new product. In the case of the mainstream industry, this business model may have so much inertia that it almost totally shapes the “sort of” vehicle that can be designed. By contrast, a new enterprise may start from scratch with an idea for a new type of vehicle – and especially in the case of teams where the skills base is engineering of technical, the process of product design and engineering leads to the business model – which may not be consciously designed, but may arise organically from the sequence of business decisions.



**Figure 124 - Business Model Design & Product Design Co-Shape Each Other**

There will always be elements of conscious and sub-conscious feedback and shaping between the vehicle design and process design. In a TNC/MNC vehicle producer, vehicle design, process design, business models and change models may all be managed by different teams of people – most likely in different offices; possibly on different continents. By contrast, by their nature, SME VMs tend to consist of very small, lean, agile tightly integrated teams – with decisions on both corporate strategy; and vehicle model strategy often being taken by the same small group. This allows synergistic decisions which affect both vehicle and process design, and business and change models to be taken together.

### 8.6.1.1 Process Design Leading (TNC/MNC VMs)

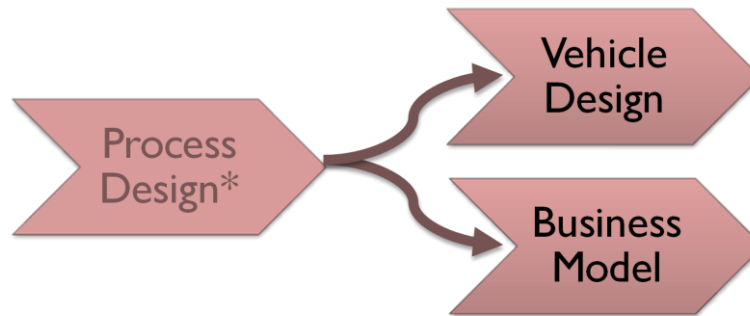


Figure 125 - TNC/MNC Vehicle Industry Model Development

In the ‘TNC/MNC VMs’ model of product development (shown in Figure 125), the design space within which vehicle solutions can be conceived is largely dictated by the large sunk investments in production technologies (denoted by the asterisk and shading) – pressed steel bodywork and the volumes of production that this entails.

### 8.6.1.2 Process as Product (Gordon Murray Design / ‘Lotus VVA’ / Axon Automotive)



Figure 126 Gordon Murray Design / Lotus VVA / Axon Model Development

There are a number of ‘business to business’ business models, where the product on sale, is not a vehicle per se, but a process, novel configuration or manufacturing system for producing vehicles. In this case, vehicles are used as a way of generating interest for the real product – which is the manufacturing system.

Whilst the T.25 might appear to be the product of Gordon Murray Design, in fact it is merely a technology demonstrator for the “real product” – which is to say the iStream process. Gordon Murray Design explicitly market the iStream process as a way of lowering the barriers of entry to the



automotive industry. Whilst not explicitly marketed as such, it can be seen in a similar vein, how Lotus' Variable Vehicle Architecture, is a solution to vehicle product – which has been licensed by the likes of Tesla, Vauxhall [for their VX220 sports car]

Outside of the UK, there are other companies that have developed 'electric vehicle' platforms. TREXA (TREXA, n.d.) are one company that has been set up specifically to promote it's 'Enertube' Electric vehicle platform, based around a spinal tube structure, which acts as both a chassis member, and also accommodates the batteries for the EV which can be removed without removing the vehicle bodyshell. Component manufacturer Magna Steyr has developed its "Mila" EV platform (Cunningham, 2009), which has already been licensed to Ford.

**8.6.1.3 Business Model Innovators (Riversimple, Bee)**



**Figure 127 - Riversimple Model Development**

Riversimple is anomalous in all of the vehicle manufacturers covered in this study, in that the Business Model design has been put first as a conscious act in trying to create a more sustainable vehicle design. This in turn has led to the process design required to realise the value proposition of the business model.

**8.6.1.4 Local Motors / 40 Fires Model Development (User Centred Design)**



**Figure 128 - User Centred Design Business Model**

In the Local Motors / 40 Fires model of vehicle development; the fundamental business model is based on the idea of user-centred design. In this model, customers design the product they would like to purchase. There are a number of different ways for arbitrating this service; however, they all share the

web as a common medium for exchanging large amounts of technical data between designer-consumers.

In this model, the vehicle manufacturer has a business model whereby certain **KEY ACTIVITIES** are performed in house; however, the design of vehicles is outsourced to consumers.

An unproven hypothesis, drawn from these conclusions, that merits further investigation, that one of the factors that allows for the rapid development of innovative business models in SME companies, is the highly integrated degree of integration between those members of the team leading design and corporate strategy; however, examination of the structures of different VMs gives clues that this is a reasonable assertion.

### **8.6.2 Business Model Canvas: Where to Start?**

Another way of communicating the same lessons of the previous section, might be to consider: Where does a business or entrepreneur start on the Business Model Canvas when designing a new business model? To conceive of this as a ‘thought experiment’, if you put those tasked with developing a ULEV, or more generically a “new venture” into a room with a blank business model and a pen – where on the business model canvas would the first mark be made? Could this single piece of information lead to new insight into the thought processes and orientation of firms’ business models?

Thinking of the process of completing a business model canvas as “Business Model Generation”, the gestalt of the canvas does not arise spontaneously. An entrepreneur or even existing company must start somewhere with the process of business model generation. To what degree does one section of the canvas dominate regarding the decisions that are made regarding the rest of the canvas?

The following characterizations are based on the perceptions of the researcher about the firms explored. These are not endorsed by the firms in the embedded cases.

Considering the case of the mainstream car industry – in deciding the business model for introducing a new vehicle to the marketplace the research would suggest that the single biggest decision in determining the direction of the firm’s business model for new vehicle release is the firm’s existing

assets. This is likely to be an unconscious process; how many in the industry when considering a new model would be brave enough to suggest to the firm's board that the vehicle is produced does anything other than make best use of the firm's existing sunk investments in tooling, equipment and knowledge.

In Figure 129 these are characterized as "asset led" business models. The primary, first or most important decision that leads other decision making on the business model canvas, is the pre-existing assets of the business. This is one perspective on a long-standing discussion in the academic literature about why incumbents fail to innovate: because new business model design is dominated by "Key Resources" the business already holds – the configuration of other components of the model being made to fit around the existing assets and the type of business model they dictate.

But what about new entrepreneurial ventures, or SME's that on the one hand do not have the benefit of existing resources, but on the other hand are unencumbered by the burden of legacy?

There are some cases in which the business model is largely based around existing relationships or key partnerships. Take the case study of Allied Electric vehicles. Peugeot's existing key partnership with Allied Vehicles produced mobility adapted vehicles. The knowledge gained through this business which relied extensively on a good relationship with a large vehicle OEM led to the development of Allied Electric vehicles. The high quality key partnership dictated much of the logic of the business model for the new venture. Similarly, the business model of Electric Car Corporation with the Cleveland, is a business model that is developed largely around a solid, high-quality relationship with a major VM: This time Citroen. To some degree these businesses are dependent on the quality of the relationship; this may involve exclusivity which constrains the partnerships these businesses could form with other OEMs. Whilst this exclusivity might not be contractual, it might be unspoken – support, favourable terms and good relationships based on mutual understanding. This extrapolates from the embedded cases as discussed. There is no empirical data to support that either Allied or ECC are constrained in any way by these relationships; but what is evident is that beyond just performing "vehicle conversions", these companies both offer a standard conversion from a single marque and we could pre-suppose that a contributory factor to the quality of this relationship is exclusivity.

Contrast this with for example Dragon Electric Vehicles, who provide one-off conversions on a range of different vehicles; this would not be considered a “relationship driven” business model, as it is clear that this firm (whilst smaller) works with a range of marques on a one-off basis and that the customer supplies the vehicle; there is not an exclusive or enduring arrangement with a single supplier.

However, in respect of the integrated, but distinct business model: conversions of imported vehicles, both Dragon Electric Vehicles and Elecscoot could be considered “Relationship Driven” in that they have relationships with overseas suppliers and it is this relationship that forms the core of this model. In Figure 129, this type of business model has been considered as ‘Relationship Driven Businesses’.

Now consider firms like Axon, Lotus and Gordon Murray Design. Decisions about the construction of these firms’ business models has been led by “Key Activities”. In the case of Axon and Gordon Murray Design and Lotus, it is a unique production process that is at the heart of the business model. In the case of Axon, both a B2C business model, in the form of attempting to bring the Axon Hatchback to market, and a B2B business model, in the form of marketing Axontex as a process are evident. However, the core of both of these business models is the unique Axon carbon fibre structural technology. Whilst a very versatile process that could be used to produce a variety of different products with widely different value propositions, the rest of the business model is designed around the key activity of carbon fibre manufacture. Similarly, Gordon Murray Design’s iStream process is a novel process which forms the core of the business model. Here, iStream is only being marketed as a B2B business model, and so far Yamaha has taken up the opportunity. Similarly, with Lotus’ the technologies that have been used on Lotus’ own vehicles have in turn been licensed by other firms, Vauxhall in the case of the VX220, Tesla in the case of the Tesla Roadster. Lotus’ B2B business model is based on its unique knowledge, its lightweight platform and its process and manufacturing capabilities.

What is interesting here, is that with a number of these B2B business models, the focus is almost exclusively on “value creation”, with a minimal B2B “customer relationship” with another brand that franchises, licenses, or sources through contract manufacture, the technology – here in many cases,

the 'value capture' and customer relationship side of the business model is wholly provided by the franchisee, such as Yamaha in the case of GMD, or Tesla in the case of Lotus. Here it is the franchisee that is wholly responsible for the customer segmentation, management of customer relationships and the customer channels.

Now attention turns to Businesses that are built around a unique 'Value Proposition'; a couple of the different embedded cases could be considered in this concept. Jevon Thurston Thorpe talked about the development of Modec's vehicles; that a key process in designing the product was the QFD process, Quality Function, Deployment at starting with a customer's needs to arrive at a value proposition that was tailored to customer needs. It could be argued that the customer was placed at the centre of the product development process, but ultimately, the focus for the business model was the specific embodiment of the Modec product.

Perhaps one of the most complicated business models of all to place in this matrix would be the "Riversimple" business model. Challenging not least because it disrupts so many areas of the dominant business model.

This leaves two remaining classifications. Customer Focused Businesses and Accountancy Led Businesses. These are more challenging definitions to apply to the car industry.

Consider the case of "Customer Focused Businesses" through the lens of Lawrence Tomlinson's transformation of Ginetta. Clearly, there is a value creation side of the business that revolves around the vehicle as a manufactured product. However, it could be argued that the transformation of Ginetta has been successful, because of a shift in emphasis of the Ginetta business model away from the "product creation" side of the business model, to the "customer relationship". Ginetta has developed the 'service' side of the business; hospitality, value added services, competitions, championships the 'Ginetta Racing Drivers Club', scholarships – a whole basket of value added services that in business model terms take the emphasis away from the physical artefact of the manufactured product and emphasize the "lifestyle" dimensions of product ownership. This is an interesting development for an

SME vehicle maker. It capitalizes on the contextual factors in the UK, a willingness to engage with car clubs and enthusiasts' organizations (p.219) but rather than these being extraneous to the firm, in the case of "unofficial" clubs, it brings these elements within the domain of the firm's business model, and turns them both into a revenue stream, a marketing opportunity and a way to build the customer relationship. This is all underpinned by a high quality product – but it is the customer focus that distinguishes Ginetta.

What would an accountancy led business model look like? This is vexing and perhaps the most challenging question to answer. We can see in other domains of business how large accountancy firms have crafted businesses by leveraging their knowledge of accountancy to run public services, private finance initiatives and other contracts on behalf of the state. A mobility business model led by accountants might therefore involve paying for mobility services in advance, with any future deviations to route or number of passengers incurring horrendous additional charges!

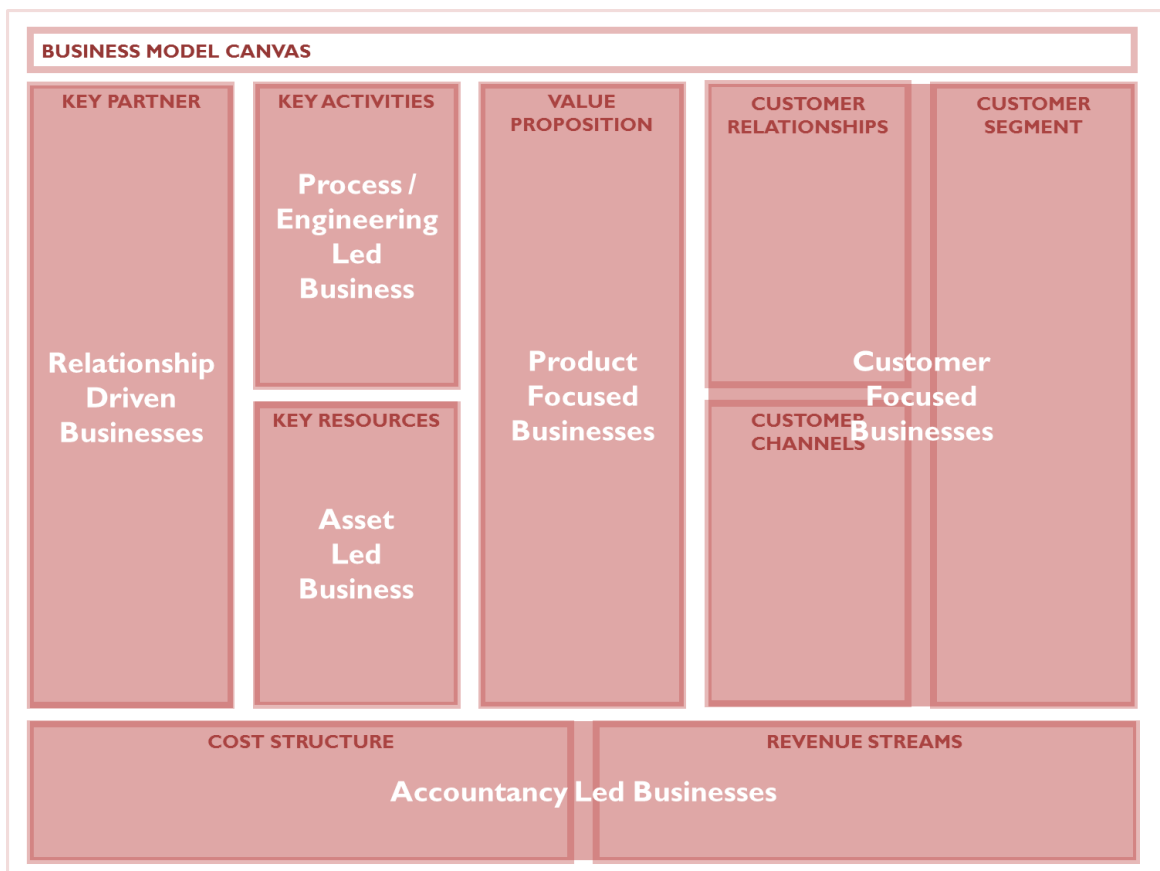


Figure 129 - Where do firms start on the Business Model Canvas?

## 8.7 Implications for Policy

Initiatives such as those by the Technology Strategy Board, are working to stimulate collaboration and encourage *technical* innovation and the trial of novel and new technologies. There is no conclusive case that novel technologies and ULEVs *will* require new business models.

However, this is a different question from whether the present business models, (that appear to be able to adapt to the sale of ULEVs) are sustainable? Although elements of the car industry's business model will change, Nissan and other TNC / MNE manufacturers are demonstrating that it is possible to produce ULEVs within the confines of the industries present business model.

Perhaps policy might incentivise more sustainable business models? In the way that company car tax is applied to benefits, perhaps there are similar mechanisms that could be deployed to encourage consumption of sustainable mobility as a *service* rather than the consumption of more green products?

Considering the incentives that are available in the marketplace; Given the low penetration of electric vehicles into the marketplace, there are a variety of incentives available to encourage consumers to buy plug-in vehicles. It is a feature of the stable socio-technical regime that the sorts of vehicles consumers are being incentivised to buy are the sort of vehicles industry is willing to produce. Namely, Class M1 vehicles. Whilst quadricycles have received mixed press in the UK, and are viewed with a degree of scepticism by consumers, perhaps there should be more incentives to encourage smaller lighter vehicles. The kei class in Japan provides one example. This could liberate more radical mobility concepts such as the EnV concept by GM; but also the smaller offerings of companies like Axon, Microcab, Riversimple – which border this lightweight regime.

Different environmental ratings systems which consider 'footprint' as well as vehicle emissions might be the way to encourage smaller, lighter vehicles. Wells, Nieuwenhuis, Nash & Frater (2010) point to the Clifford-Thames/CAIR-BRASS Environmental Rating System for vehicles as one potential example, that factors in the 'footprint' of vehicles, in addition to emissions. Such a measure may incentivise manufacturers to make smaller, lighter vehicles.

This study did not set out to be an appraisal of ULEV incentives in other markets, therefore the ideas and policy suggestions that have been drawn from other markets are not exhaustive, thorough or comprehensive. It is interesting to see in the US, how state-by-state targets for ZEV manufacture have incentivised existing automakers to produce ZEV's – even though the vehicles they have produced have reluctantly been called “compliance vehicles” (Greiling & Ohnsman, 2013).

It is clear, that this mechanism has helped in redistributing resources from reluctant regimes to new niches. The sale of credits to large automakers who are slow to transition has formed a sizeable revenue stream for Tesla who earned \$85 million in the first quarter of 2013 (Greiling & Ohnsman, 2013) for sale of ZEV credits to other firms despite being so small, that Tesla's own operations fall below the level required for the regulatory regime.

There is understandably real political reluctance from industry faced with this level of regulation. In the US, Edward Cohen, Honda's vice president for government and industry affairs has called the policy “inherently risky” noting that it “*directs manufacturers to offer consumers technology options along a predetermined time frame and with specified numbers, notwithstanding whether the technology and market are ready.*”. However, taking an integrative view of business models and transitions, it has created a revenue stream for the emergent niches, and furthermore by putting a small number of very cheap vehicles on the marketplace, it is encouraging consumers to engage with new technologies. Assuming the “learning perspective” view of transitions, and combining it with the contextual data that in the UK, once drivers experience ULEV performance, they are more satisfied with it than they anticipate – such a policy move may help accelerate the learning processes of both manufacturers and consumers and bridge the 9X effect (Gourville,2006).

Whilst there would probably be political reluctance in the UK to do anything that negatively impacts vehicle manufacturing in the UK (when the sector is seen as so key to helping rebalance the UK economy), it would seem an effective way of helping to support niches on the back of larger companies that may be reluctant to innovate.



## 8.8 Chapter Summary

This chapter provided a comparative analysis of the two case studies examined in this thesis, and viewed the cases through the lens of the six research questions that were considered in section 1.3 (page 40).

The first three research questions, and hence themes explore in this analysis, all related to issues surrounding the business models of the firms examined. In the first section (8.1), the role of business models in the transition to sustainability were examined. In the second section (8.2), the business models in the UK car industry were examined. The third section (8.3), broke the business models down, to look at individual components of automotive business models. Section 8.4 then considered what understanding the 'transitions framework' could bring to the two cases examined. Section 8.5 considered the role of 'incumbents' and 'insurgents' through the lens of their business models. Section 8.6 then considered the role of product, process and business model 'design'.

This then led to some considerations for how this thesis might speak to a policy arena.

The work of this chapter is summarised in Chapter Nine, which provides a summary of the conclusions of this work. Chapter Ten takes the themes that have been explored and looks for future research directions. This speaks to both the inadequacies in the current state of the literature, but also addresses those elements of the research themes that this work has touched on, but failed to comprehensively address.

## Chapter 9: Conclusions

### 9.1 The Overall Conclusion of the Thesis

The cases examined within this thesis, are indicative of a broad spectrum of the 'UK motor vehicle industry'. There is a diversity of vehicle technologies that could be classified as 'Ultra Low Emission Vehicles' being introduced by the firms examined. Some vehicles have also been included, which whilst they fall outside of the strict definition of 'ultra low emission vehicles' mark a significant improvement on their marques incumbent models. Whilst these models are at varying stages of readiness, there is clearly concerted investment by the industry in bringing ULEVs to market.

Whether these ULEVs can be considered to be sustainable is another question. This thesis made no attempt to appraise the relative environmental performance of a range of solutions, but as Hugo Spowers founder of Riversimple has said 'Less unsustainable is not sustainable'.

The environmental value proposition of many ULEVs is a function of vehicle weight. Looking at the UK car manufacturers in the broadest possible sense, there are a range of chassis and bodywork technologies employed amongst smaller 'SME' vehicle producers, and there are some promising lightweight vehicle technologies that are currently being incubated. These technologies are well suited to production on smaller scales than is economical within the constraints of the industry's dominant business model. As the scale of production increases, manufacturers converge upon pressed metal bodywork – with some premium 'volume' manufacturers using lightweight aluminum – but in the main, pressed steel bodywork is the only bodywork technology employed by the high-volume mass market UK car manufacturers. It is this 'key activity' which defines many of the features of the mainstream car industry's business model.

ULEVs can clearly be introduced within the framework of the mainstream car industry's business model with minor accommodations. It would appear that the vehicle technologies that are enjoying success in the UK context, are plug-in electric and plug-in hybrid vehicles. This could in part be explained by the extant charging infrastructure that is already in place. Range extended electric vehicles add a great deal of familiarity, and are less of a 'leap of faith' for consumers (and therefore, perhaps

for manufacturers too). That said, in sustainability terms they are not an 'optimized' solution, due to the weight of the additional range extender.

There appears to be no appetite amongst UK manufacturers for 'battery swap' type solutions (this point has been driven home during the course of this research by the collapse of Project Better Place). Furthermore, whilst there are limited deployments of hydrogen filling stations these remain for technology demonstration, rather than a widespread solution. Both of these innovations would require radical changes to the automotive regime – in terms of infrastructure, partners and perhaps business models. There are no signs of this happening in the UK in the near term.

Considering electrified drivetrains (whether pure EV / hybrid) as the 'value proposition' which is enjoying significant interest as a means of decarbonizing vehicles in the nearer term; one of the barriers to technology adoption appears to be the cost of battery technology. One approach is to focus on technology improvement, reducing the cost and improving the power density of EV batteries. However, by light-weighting vehicles, EV performance is increased for a given value of batteries.

Another school of thought, suggests that exotic technologies are not necessary if vehicles can be made lighter and smaller – such is the approach of Axon automotive. With a lightweight vehicle, ICE emissions improve. There is scope for light weighting with high strength steels, and the industry is already examining ways to reduce vehicle weight to improve vehicle efficiency. However, a more radical step-change in light weighting may require a change in technology. This may have significant ramifications for industry business models.

Considering the present situation though, there is little evidence of major change to the industry's stable business model. That said, the case studies identify some examples of small 'business model innovation(s)' to various business model components. As the BMW case outlined, there is an awareness amongst volume producers that ULEVs may require 'evolution' of the stable business model; to that end they are undertaking 'experiments' to inform the future direction of their business.

As BMWi demonstrates, there is a willingness in the industry globally to engage in bold ventures, but there does not seem to be a fundamental transformation of the bodywork / chassis key activities in evidence in the UK context.

Considering the UK's role in the international context, it is significant that the UK does not possess an 'indigenous' national champion brand. Decisions over the 'business models' of UK firms are heavily influenced by the strategies of their parent companies overseas. Yet, many firms continue to invest significantly in the UK automotive industry with the UK seen as a 'regional gateway' to Europe and the Middle East.

The UK, as a result of its vibrant heritage of smaller SME, niche and specialist vehicle manufacturers has an interesting pool of talent from which future challenger business models may be developed. Some of these firms target tight niches, which are likely to endure. Some of these firms have business models which produce 'compromise' ULEV products [converted vehicles], and these business models may prove less durable as manufacturers acquire capabilities to produce ULEVs of their own. However, within this set there are also plans for some very radical automobility concepts and business models. What this thesis highlights is that whilst there is the capability for a range of smaller, more radical vehicles, there is not currently the policy context to support 'small' sub class-M1 vehicles. This is a point that was reinforced by Wells, Nieuwenhuis, Nash & Fraser (2010).

Furthermore, as will be explored in the subsequent sections, there is little mechanism to support 'business model innovation', the present focus is on supporting 'technical innovation'.

There is no conclusive prove that ULEVs *will* require new business models. There is however, a great deal of scope for ancillary business models which support the transition to ULEVs. In other sectors, there is evidence that business model innovation can completely change the market dynamics of a sector; at some future point, this may be the case with automobility – but at the moment, this doesn't appear to be the case.

## 9.2 The Contribution of the Thesis to the Literature

This thesis contributes a detailed cross-case analysis of UK vehicle manufacturers seeking to introduce Ultra Low Emission Vehicles to market. In doing so, it presents a snapshot of an industry in the very early stages of transition and contributes both to the growing number of ‘business model’ case studies (and in this respect, is interesting for the number of embedded cases and structure of the case study design), but also speaks to the literature of socio-technical transitions, in providing a case study of a sector that is potentially (!) in the very early stages of transition.

At present, whilst this thesis collates together a number of innovative product and business model concepts that could potentially challenge the mainstream industry’s business model, there is no evidence to suggest any of these concepts are in the process of transitioning to large scale production.

This thesis makes a theoretical contribution to the literature in demonstrating how the ‘business models’ literature can be integrated with the ‘socio technical transitions’ literature, in a meaningful way as a way of interrogating an industry sector in transition. In doing so, it suggests a model of how Osterwalder’s (2004) Business Model Ontology can be viewed with respect to the literature on Socio-Technical transitions, and provides a model of interpretation that bridges these two fields – positioning the multi-level perspective as a tool for understanding the ‘macro’ view of an industry in transition, whilst the business model canvas presents a ‘micro’ level view of the firm in transition.

It also presents a novel commentary on the relationship between ‘business model’, ‘process’ and ‘product’ design, which is a novel way of conceptualising the technological continuity inherent within the automotive industry – but also, the ‘business model continuity’ of the mainstream industry.

It also makes an interesting methodological contribution, in showing how the novel ‘Citation Network Analysis’ approach can be used in a Business & Management literature review, and this is covered in greater detail in Appendix 2.

### 9.3 Reflections on the Theories Used in the Thesis

As noted in the literature review, the broad variety of interpretations of the “business model” concept in the literature make its use in practical work problematic in many respects. As was discussed in the chapter on methodology, there are significant challenges in using the “business model” concept as a medium of information exchange, when researcher and interviewee have no shared ontology of the business models concept. It was found in the practical empirical work of this thesis that the term ‘business model’ was used widely and in many different ways in industry – and this experience appears to validate the prevailing view of the literature.

That said, this thesis has employed the ‘business model canvas’ extensively as a tool for the interpretation of firm’s logic. It was found that some practitioners had come across this tool before; but there is not a widespread shared notion of the term ‘business model’. One of the debates which continues in the literature, is how to integrate thinking about ‘sustainability’ into the concept of a business model ontology. This is problematic, as ‘cradle to grave’ life cycle analysis involves the consideration of whole value chains. Different business models can occupy different sections of that value chain. This thesis has considered this within Osterwalder’s (2004) canvas, but there is clearly potential for alternative ontologies that encompass sustainability more fully.

It has already been noted in the literature review, that one of the deficiencies identified with the socio-technical transitions literature as a ‘tool’ for practical policy, is that whilst it provides a sound framework for the post-hoc interpretation of historical transitions, it is harder to use as a tool for interpreting on-going transitions. The UK car industry is at a very early stage of the transition to ULEVs. If we follow the path of historical emissions reductions, it would seem obvious that future mobility will be lower carbon, the indications from this thesis are that incumbent business models are slowly adapting to new ULEV realities. At this stage, it is hard to predict what that transition will look like. Whilst there are some interesting ideas and concepts which could prompt a more radical transition, at the moment it appears that none of these ‘niches’ have managed to develop, in the same way that a firm like Tesla in the U.S. appears to be a credible new entrant to the EV market.

## 9.4 Policy Implications Arising From the Thesis.

There are already incentives in place to encourage consumers to purchase ULEVs. Examples in the UK include the plug-in car grant, exemption from London congestion charging and tax reliefs. However, from a Sustainable Consumption and Production perspective, these incentives all focus on incentivizing the **purchase** of a certain **sort** of ULEV.

Here, there are two issues; the first is that these schemes incentivize purchase and hence consumption. What policy levers could support newer 'mobility services' business models – tax incentives and reliefs? How could 'business model innovation' be incentivized? If appropriate policy levers could be devised that move beyond technological innovation, towards business model innovation (socio-technical innovation), then perhaps the "system efficiency" of UK private mobility could be improved at a greater rate than was possibly with just technological innovation.

The second, is the sort of vehicles that manufacturers are being incentivized to develop. OLEV is clear that it is technology agnostic in its support for a range of ULEVs, however, within current support mechanisms there is a focus on 'plug in' vehicles with electric drivetrains. One of the embedded cases suggests that ultra-low emission would be achievable with ICE technology if there was a concerted effort to 'lightweight' vehicles. Whilst there is a focus on ULEV powertrain in policy, perhaps a more direct focus on lightweight chassis and bodywork technology would be welcome. Lightweighting was one of the scenarios considered by Wells, Nieuwenhuis, Nash & Frater (2010) to reduce vehicle emissions standards to sub 80kg/CO<sub>2</sub>/km by 2020. From a business model perspective, this would involve significant changes if manufacturers were required to achieve standards which were not possible within the constraints of the industry's present activities which are vested in pressed steel. This would involve industry and business model transformation.

Focusing on Class M1 vehicles is clearly a strategy which is designed to mitigate against exposure to risk – quadricycles have been heavily criticized in many sections of the media. That said, the regulatory burden of introducing a Class M1 vehicle is significant, and a barrier to new entrants. Nurturing this bottom end of the market through policy may be a way to nurture SME firms to grow.

## Chapter 10:

### Further Research

In this chapter, some of the opportunities raised for further research that has arisen as a result of this Ph.D research are described with some suggestions for future research directions.

#### 10.1 Integrating Sustainability into the Business Model Ontology

As this research has developed, the 'Business Models' literature and academic community has grown substantially. It appears that there is a widely observed trend in the literature towards 'Business Model Innovation' and an implication that the perpetual re-invention of business models is the key to a sustainability [if it represents the ability to maintain *adaptive capacity* (Holling, 2000)].

The shortcomings of the present automobile industry lead this author to ask whether in fact perhaps we should be searching for more *durable* business models that do not require perpetual reinvention as a result of environmental constraints; or by contrast, do we need to intentionally craft more fragile enterprises – that should they reach constraints by virtue of their unsustainability fail 'quickly and tidily' allowing other ventures to reinvent the configuration of their resources. This has direct implications for policy, and is a particularly poignant talking point given the extents of recent industry bailout(s).

Despite the undoubted recent surge of interest in business models as a concept, there are many important and fundamental questions that still remain unanswered. As with many challenges in business and management, this exploration leads to challenges at several different levels of thought.

At the philosophical and theoretical level, the business model descriptions popularised by Osterwalder & Pigneur (2010) do not explicitly recognise sustainability within their framework – and there is great potential for further research into how sustainability values can be codified within a business model. This raises a number of important philosophical questions in relation to the relationship between sustainability and business. Should sustainability be considered as a “bolt on” – another box in the business model description to tick in some way; or should sustainability be considered more holistically



as an integral part of every business model component? Findings from this research suggest the latter is potentially more likely to be true, however, this is a debate for discussion.

At the practical level, the question still remains unanswered as to what future business models will lead to the mass market adoption of ULEVs and whether this technology can be indefinitely accommodated by evolutionary changes to the present mass-market car industry business model; or whether a radically different conception of automobility is required. A longitudinal study would be more revealing examining business model evolution over time.

## **10.2 How do the business model concepts from ‘SME vehicle manufacturers’ enter the mainstream?**

Looking outside the automotive industry, we can see how new entrants to a marketplace, with radically innovative business models can gain market share rapidly. As noted in the Liberty Electric Vehicles Embedded Case (See Page 329) Medion became the only European company to have a significant presence in the European PC Market; a position that was gained in just a few years. There are numerous other examples in the literature, of new entrants with disruptive business models rapidly gaining market share, and edge over established incumbents; but in an industry with such high barriers to entry, is this a pattern that we are likely to witness in the ULEV vehicle industry?

Even in the short period during which this study was conducted, we have witnessed some interesting shifts in the ownership and alliances between various smaller vehicle concerns.

The acquisition of the engineering team of Modec by Liberty Electric Cars (discussed on pages 333 and 348) shows how consolidation of SME ULEV manufacturers can strengthen the **VALUE PROPOSITION** of both parties. As (Seear, 2011) notes – the complimentary nature of both companies will make them a ‘*formidable player*’ in the EV marketplace. This raises some interesting questions about whether SMEs will see mergers and acquisitions as a route to increasing their presence in the marketplace – and ability to challenge larger companies.

Smiths Electric Vehicles reverse takeover by American subsidiary (discussed on page 353) is also noteworthy.

### **10.3 Business Models for Vehicle Efficiency**

This research has been a comparative study between TNC/MNC and SME vehicle manufacturers introducing ultra-low emissions vehicles into the UK marketplace. A variety of different technology pathways have been considered to low-emission.

In some ways though, perhaps ultra-low emission vehicles fall short of the mark. Their low emissions are predicated on low carbon electricity; and the energy regime also requires a transition of its own. Furthermore, low carbon is not to say without impact. Even low carbon electricity has manifold environmental impacts. For this reason, there are some voices that have highlighted the need to transition to *ultra low energy vehicles*; not just basing vehicles on low emission technologies, but also ensuring their efficiency through lightweight design. This was particularly emphasised in interviews with Prof. Stephen Cousins of Axon Automotive, Hugo Spowers of Riversimple and Stephen Voller of Bee Automobiles.

In interviews, it was also suggested that the true benefits of ULEV technologies will not be unlocked by the present vehicle bodywork technologies. Heavy vehicles require large batteries or fuel cells, which in turn makes the capital cost of vehicles prohibitive. There may be synergies in using lighter vehicle technologies that enable the use of smaller, cheaper drivetrains. It has already been discussed how this might affect the value creation components of companies business models.

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## Appendix 2:

### A Citation Network Analysis of the Business Models Literature

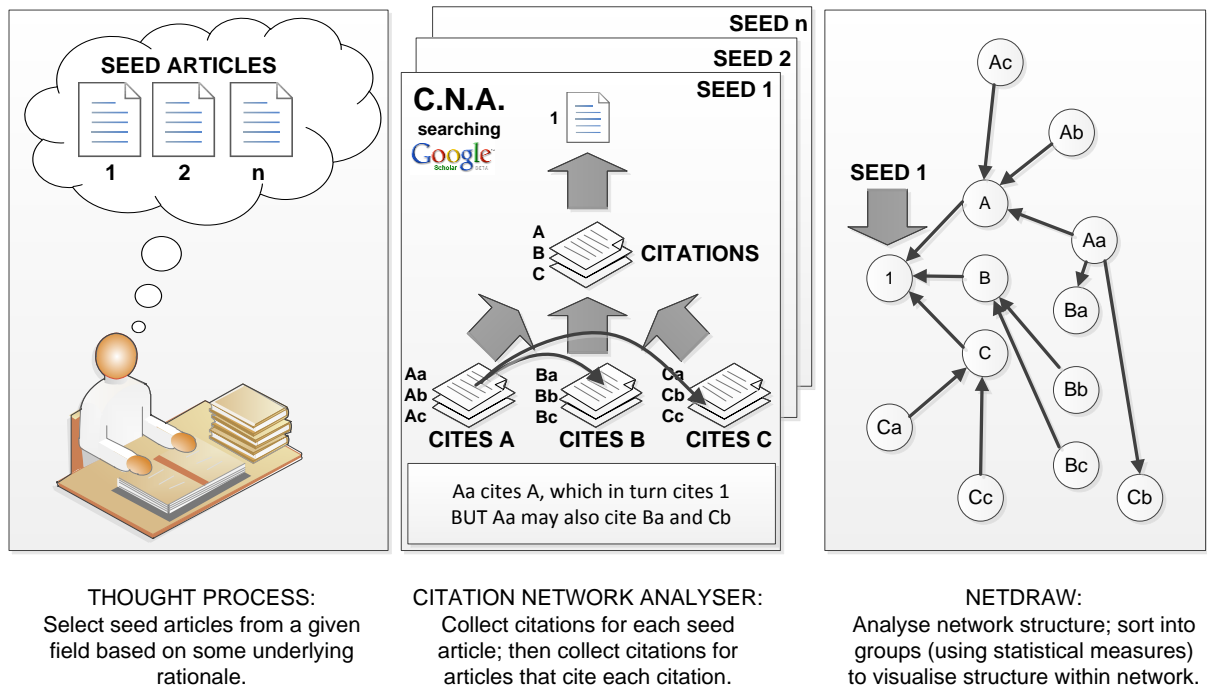
This Appendix borrows heavily from (Harper & Peattie, 2011) – work which was conducted concurrently with this thesis. Necessarily, whilst the source data and outputs differ widely, much of the explanation of methodology – written by the author – is identical.

The Business Model Literature is a relatively contemporary one, and has evolved rapidly whilst this piece of research has been conducted. As noted earlier, this analysis was conducted at an early stage of the research before some very significant events in the business model literature, namely, the publication of a number of journal special issues and an explosion in the number of publications addressing ‘business models’ in the broader context. Changes to Google’s terms of access curtailed the use of the Citation Network Analysis software part-way through the study, and, as such, it could not be used in later iterations of the literature review, nor in the evaluation of transitions.

The traditional method of literature review is that the researcher reads an article, looks at the references embedded within an article, finds novel and interesting citations and then explores the literature further. Whilst this is good at providing a ‘depth’ of understanding, and investigating specific and key pieces of insight, this method does not give a wide overview of the ‘problem space’ (Oh, Ro, Park, Lecy, & Rosso-Llopart) of a given field of literature, nor does it give any impression of the shape and significance of the literature field.

Citation Network Analysis is a technique for knowledge exploration that helps researchers understand and visualise the significance of different pieces of knowledge in any given field. This work applies the program ‘*Citation Network Analyzer*’ (CNA), which was developed at Syracuse University by Jesse Lecy in 2007 (and uses version 3.0.1). CNA uses existing analytical methods developed in the field of bibliometrics, but adds a novel way of collecting citation networks through snowball sampling, using the *Google Scholar* search engine, in order to build compact and representative citation networks. The snowball sampling algorithm it applies was developed by a group of computer science postgraduates

at Carnegie Mellon University. An overview of CNA's role within the Citation Network Analysis is shown in Figure 130.



**Figure 130 - Overview of the Citation Network Analysis Process, Reprinted from Harper & Peattie (2011)**

The Citation Network Analyser constructs a database of references (a snapshot of which is illustrated in Figure 131), with coding information on the relationship between those references using an automated algorithm.

It does this by first searching for a seed article on the “Google scholar” web service. The importance of the candidate seed articles for analysing the relationships within a given domain means that a central issue for citation network analysis concerns the basis on which those seed articles are chosen. In previous work on citation networks, a number of techniques have been used to select seed articles, including solicitation of expert opinion and selection by keyword search. However, both of these approaches are open to human and machine bias.

As a data source, CNA uses *Google Scholar*, which is freely available, easily accessible and indexes most academic databases (Noruzi, 2005). Sampling is not random, but based on PageRank, a measure of centrality or importance that is determined by *Google Scholar*. The PageRank measure of centrality represents the probability assigned to how often a web surfer would click on a particular link, based on several characteristics (Brin & Page, 1998). As PageRank gives higher weights to those publications cited by important papers and in shorter reference sections, it has the potential to develop citation patterns and networks that focus on the most important articles (Maslov & Redner, 2008). This makes *Google Scholar* a useful data source with which to perform citation network analysis, even though it also has some significant limitations. Only nodes (points) with a high degree of PageRank centrality are retained by CNA, which helps to create relatively compact samples that still retain the key features of the full network.

The program relies on gathering a set of 'seed' articles which are identified at a historical point in a given research field. Once the seed documents have been identified, the remaining sampling parameters that must be specified, when using CNA, are the levels of data to be collected and the percentage of citations sampled at each level. The sampling rate must also be specified to control the percentage of articles that is collected at each level. Since the number of identified articles increases exponentially down the levels of sampling, even a modest percentage can create a very large sample. As the levels of sampling and the number of documents gathered increases, they tend to become more diverse and potentially less closely related to the core issues considered by the seed articles at the lower levels. Therefore, sampling at a rate of 10-20% is generally considered optimal for data management and analysis (Lecy, Jesse Lecy Homepage, 2010)

The program then forward-samples in time, analysing the documents which cite the seed articles (Level one sampling), the documents which in turn cite the Level one documents (Level two sampling) and so forth. (Shown in the central box of Figure 115) As the levels of sampling increase, so the number of documents gathered becomes greater in number, more diverse and potentially less relevant to the core subject area under investigation. (Lecy, Mergel, & Schmitz, 2009) have established that three

levels of sampling tends to create the optimum data set for analysis. The list of data, which has been crawled and stored in a database is then validated, with any missing fields being completed. Where there are similar entries for the same paper that appear in different formats; for example Harper, G.D.J. (2010), Gavin Harper (2010), Harper, Gavin (2010), these are merged into a single entry. After this step, a relational database is created, with details of a given number of search results which illustrates how different articles in the literature relate to each other.

The next step is representing this data. This can be presented in a simple tabular form that can be used to sort the list of references; for example by such metrics as citation frequency (as shown in Figure 131). This yields some interesting bibliometric statistics, which can be used to make assessments of significance in the data; however, there is a layer of much richer information that can be gleaned when the data is exported into a graphing package, in order to visualise two-dimensionally, the relations between different pieces of literature in the field.

However, the process of constraining the analysis by searching for particular terms within particular journals creates a risk that scholars search for knowledge by relying on familiar and conveniently available sources. Although this provides a way of coping with the volume of available knowledge and the rate at which it is expanding, Lecy, Mergel and Schmitz (2009) liken it to the joke about a person's tendency to look for an item where the light is best, rather than near where they lost it.

One way to reduce the bias created by constraining and bounding a search is to engage in the form of automated bibliographic analysis. This has led to the development of automated citation network analysis software that systematically explores the literature of a particular field and generates insights into the state of the research paradigm within it. It should be noted that, although citation network analysis is helpful in identifying the relationships within a field of literature, it does not tell all that is needed to be known about the nature of those relationships. For example if one journal article cites another, it is not obvious from a citation network analysis whether the citation is to confirm or refute the cited research.

Title	First Author	Journal	Volume	Number	Pages	Year	Publisher	Type	CitedBy	Collect...	SearchLevel
Why business models matter	Magretta, J.	Harvard business review	80	5	86--93	2002		article	512	51	0
The power of business models	Shafer, S.M.	Business horizons	48	3	199--207	2005	Elsevier	article	169	17	0
The business model concept: theoretical underpinnings, present, and future	Hedman, J.	European Journal of Information Systems	12	1	49--59	2003	Nature Publishing Group	article	180	18	0
Changing business models: surveying the landscape	Osterwalder, A.	Communications of the Association for Information Systems	16	1	1--25	2005	Citeseer	article	250	23	0
Clarifying business models: surveying the landscape	Linder, J.C.	{Institute} Working Paper	0	0	2001	2001		techreport	129	13	0
The Business Model Ontology-a proposition in a domain-independent language	Osterwalder, A.	Academic Dissertation, Universite de Lausanne	0	0	2004	2004	Citeseer	article	276	28	1
Exploring the fit between business strategy and business model	Zott, C.	Manuscript in preparation	0	0	997--1...	2006	John Wiley & Sons	article	14	1	1
InterGrid: A case for interconnecting islands of G2B and G2C	Patel, A.G.	Concurrency and Computation: Practice and Experience	20	8	302--314	2004	Palgrave Macmillan	article	76	8	1
The demand chain as an integral component of the business model	Walters, D.	Journal of Consumer Marketing	21	7	465--475	2004	Emerald, 60/62 Toller Lane, Bradford, ...	article	32	3	1
Business model design and the performance of e-business	Zott, C.	Organization Science	18	2	2007	2007	INFORMS	article	172	7	1
Customer evaluation of application services provision	Currie, W.L.	Journal of Information Technology	19	1	39--58	2004	Palgrave Macmillan	article	17	2	1
Reputation risk: it is the board's ultimate responsibility	Dowling, G.	Journal of Business Strategy	27	2	59--68	2006	Emerald, 60/62 Toller Lane, Bradford, ...	article	12	1	1
Strategic entrepreneurship: Exploring different perspectives	Kuratko, D.F.	Entrepreneurship Theory and Practice	33	1	1--17	2009	John Wiley & Sons	article	20	2	1
Mobile service innovation and business models	Bouwman, H.	Journal of International Entrepreneurship Research	4	2	69--81	2007	Springer	article	11	1	1
Strategic risk analysis-a field version	Emblemsvag, J.	Management Decision	40	9	842--852	2002	Springer Verlag	book	35	4	1
Choice and change of measures in performance measurement	Molina, M.A.	Management Accounting Research	15	4	441--469	2004	Elsevier	article	52	5	1
Do some business models perform better than others?	Weill, P.	MIT Center for Coordination Science	26	0	4615--06	2004	Citeseer	article	19	2	1
Assessing business model concepts with taxonomic methods	Makinen, S.	Management Research News	30	0	735--748	2007		article	12	1	1
Business models and market entry mode choice	Ojalao, A.	Journal of International Entrepreneurship Research	4	2	69--81	2007	Springer	article	11	1	1
Value capture and value networks in Open Source software	West, J.	Journal of International Entrepreneurship Research	4	2	617--628	2004	IEEE Computer Society	article	19	2	1
Modeling business strategy in e-business systems	Bleistein, S.J.	Conceptual Modeling for Advanced Applications	0	0	1267--...	2006	Springer	article	10	1	1
Design of a RFID-based ubiquitous comparison system	Lee, K.	Conceptual Modeling for Advanced Applications	0	0	32--40	2005		book	14	1	1
Organizational transformation through business model innovation	Keen, P.	International Journal of Accounting Information Systems	6	3	177--195	2005	IEEE Computer Society	article	23	2	1
Enterprise risk management: A systems-thinking perspective	O'Donnell, E.	International Journal of Accounting Information Systems	6	3	177--195	2005	Elsevier	article	19	2	1
Application service providers: a model in evolution	Desai, B.	International Journal of Accounting Information Systems	6	3	177--195	2005		book	18	2	1
Value creation from application services provision	Currie, W.	International Journal of Accounting Information Systems	6	3	177--195	2005		book	9	1	1
Strategy and business models: What's the difference?	Seddon, P.B.	International Journal of Accounting Information Systems	6	3	177--195	2005		book	28	3	1
Networked enterprise: A new business model for the 21st century	Chung, W.W.C.	International Journal of Accounting Information Systems	6	3	267--280	2004	Elsevier	article	60	6	1
The fit between product market strategy and business model	Zott, C.	Strategic Management Journal	29	1	1--26	2008	John Wiley & Sons	article	60	6	1
The relevance of intellectual capital disclosure: a case study of the S&P 500	Buhk, P.N.	Accounting, Auditing & Accountability Journal	16	1	49--56	2003	Emerald, 60/62 Toller Lane, Bradford, ...	article	61	6	1
An SME Perspective of Vertical Application Services	Lockett, J.N.	International Journal of Enterprise Information Systems	1	2	2005	2005	JGT Publishing, 701 E. Chocolate Ave, ...	article	9	1	1
Supply chain project management: a structured approach	Ayers, J.B.	Information Systems and e-Business Management	7	2	171--198	2009	Springer	article	11	1	1
Strategic reasoning about business models: a case study of the S&P 500	Bala, H.	Information Systems Research	18	3	87--101	2007	Springer	article	24	2	1
Assimilation of interorganizational business processes	Lo, A.	Conceptual Modeling ER 2007	0	0	87--101	2007		article	12	1	1
From business models to service-oriented design	Vaccaro, V.L.	International Journal on Media Management	6	1	46--58	2004	Routledge	article	34	3	1
The evolution of business models and marketing strategies	Molina, M.A.	Contemporary Accounting Research	24	3	935--982	2007	Gabler Verlag	article	21	2	1
Causality in Performance Measurement Models	Bach, N.	Electronic Markets	16	2	154--168	2006	John Wiley & Sons	article	8	1	1
Relations among Measures, Climate of Control, and Business Model Innovation	Wachos, P.	International Journal on Media Management	5	2	91--99	2003	Routledge	article	14	1	1
Integrating new media and old media: Seven observations	Kim, E.	Journal of Management	30	5	2004	2004	South Management Assoc	article	22	2	1
The Applicability of Porter's Generic Strategies to the Internet	Walters, D.	INTERNATIONAL JOURNAL OF PHYSICAL EDUCATION	34	0	219--229	2004	Emerald Group Publishing Limited	article	15	2	1
New economy-new business models-new approaches	Dholakia, U.M.	Tilg({\a}ndig p({\a} www. oecd. org. ...	2340	0	2006	2006		article	11	1	1
Competing through business models	Casadesu-Masa, ...	Journal of Systems and Software	79	3	362--378	2006	Massachusetts Institute of Technology	article	10	1	1
A multi-attribute value assessment method for the evaluation of business models	Bleistein, S.J.	International Journal of Operations & Management	27	8	802--825	2007	Wiley-Blackwell	book	40	4	1
What is e-business?: how the internet transforms business	Li, F.	Proceedings of the 18th Bled eConference	0	0	6--8	2005	Citeseer	article	13	1	1
Towards a contingency approach to performance measurement	Gordijn, J.	Proceedings of the 18th Bled eConference	0	0	273--286	2007		book	8	1	1
Comparing two business model ontologies for design	Cagnina, M.R.	International Journal of Project Management	26	5	497--508	2008	Elsevier	book	83	8	1
How to Compete in the Metaverse: The Business Model of Second Life	Lepp({\a}nen, M.	International Journal of Project Management	26	5	2--2	2007		book	2	1	1
A framework for understanding and analyzing e-business models	de Reuver, M.	International Journal of Project Management	26	5	497--508	2008	Elsevier	book	13	1	1
Impact of services on project business models	Artto, K.	International Journal of Project Management	26	5	389--404	2007	Inderscience	article	6	1	1
Towards a classification of resources for the business model	Seppanen, M.	International Journal of Project Management	26	5	389--404	2007		article	6	1	1

Figure 131 - Citation List from Citation Network Analysis  
 Note, this does not display the information about the relationships between citations.



Whilst the citation list display does not show the relationships between the pieces of literature, their relationships are captured in database form, however, the tabular format does not lend itself to easy interpretation of that type of data. For this reason, the database is imported into the “Netdraw” software (represented in the last box of Figure 116). The software creates a diagram consisting of nodes (points) joined by arrows, which signify the links between nodes and the direction of the relationship. In order to understand the significance of different types of nodes, they can be highlighted in a number of ways. The software allows the node size to be adjusted according to how many citations each article has received. Furthermore, it is possible to highlight the nodes in different colours. This can be useful when, for example, if a researcher wants to sort the literature into different sub fields. This can be done in an automated manner, using a number of statistical measures, which can be used to divide the data sets by different metrics. The software also aids in the interpretation and analysis of the relationships within the network and allows a number of different issues to be explored; for example, the extent to which a field of knowledge exhibits theoretical coherence, whether or not knowledge within a field tends to be self-referential, and whether knowledge tends to spread over time within fields or remain ‘*captured*’ by specific journals..

From this combined analysis of descriptive statistics and graphical network interpretation, the researcher gains knowledge about the wider field of literature through the relative positioning of different articles and their significance in relation to one another. Through interpretation of the network structure and density of links, it is possible to gauge what literature the community sees as “central” to the domain of enquiry.

Automated citation network analysis is a relatively new and evolving technique which is being applied to a range of fields in order to try to understand them better, including public administration (Lecy, Mergel, & Schmitz, 2009) and public health (Harris, Beatty, Lecy, Cyr, & Shapiro, 2010). It has also been applied in an ambitious project to map all scholarly activity related to sustainability by using the Web of Science, the Institute for Scientific Information’s Web-based user interface for their citation databases (Kajikawa, Ohno, Takeda, Matsushima, & Komiyama, 2007). A key advantage of automated approaches is that they are better able to explore and visualise patterns of scientific collaboration and possible overlaps across different fields.

## Evaluating the Business Models Literature

Much of the contemporary business models literature has grown out of the new perspectives on business afforded by the internet. However, some of this literature was found to be very specific to an ICT / Information Systems context and, as such, was not completely relevant to the more general understanding of Business Models.

The selection criteria for the articles was based on examining the five most highly ranked articles on Google Scholar for the term “business models”, whilst excluding any articles which heavily leaned towards an ‘information systems / eBusiness perspective’. The reason for this is that the early business models literature had grown largely out of discussions about how internet technologies were shaping and disrupting business models, whereas, the aim of the Citation Network Analysis was to find those articles that produced a broader discussion of business models.

Seed Article	Citation	Type	Citation Count
Why business models matter	(Magretta, 2002)	Journal Article	512
Clarifying business models: Origins, present, and future of the concept	(Osterwalder, A; Pigneur, Y; Tucci, C.L., 2005)	Journal Article	169
The business model concept: theoretical underpinnings and empirical illustrations	(Hedman & Kalling, 2003)	Journal Article	180
The power of business models	(Shafer, Smith, & Linderb, 2005)	Journal Article	250
Changing business models: surveying the landscape	(Linder & Cantrell, 2001)	Working Paper	129

Table 33 - Seed Articles for initial Citation Network Analysis

Out of the list of articles that were generated, “Citation Count” was used to analyse the ten most cited articles from the sample. Using the “Netdraw” software, the location of these ten articles was found within the network that remained, once the seed articles were produced

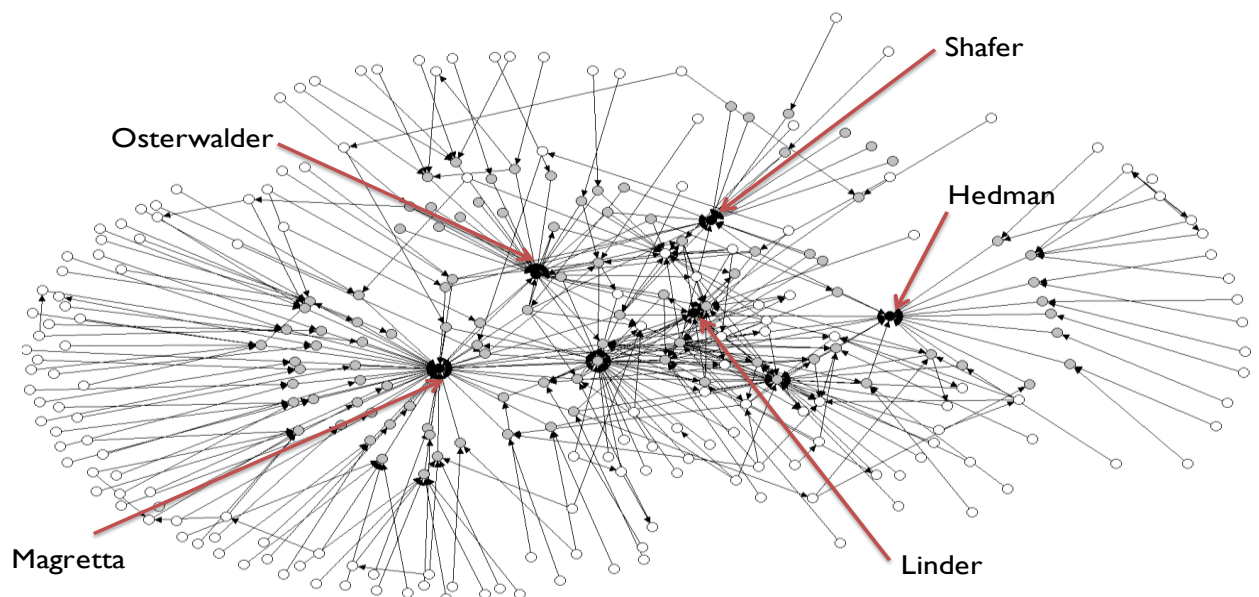
Below is the table of articles that was produced, as well as an analysis of the graph that was generated by the Netdraw software. The steps that were used to “unpack” the graph and the attempts to derive useful information from the graph is set out.

Seed Article	First Author	Type	Citation Count	Level
An e-business model ontology for modelling e-business	Osterwalder, A	Book	300	I

The business model ontology – a proposition in a design science approach	Osterwalder, A	Journal Article	276	1
Entrepreneurship and dynamic capabilities, a review, Model and Research Agenda	Zahra, S.A	Article	216	2
The entrepreneur’s business model: towards a unified perspective	Morris, M	Article	212	2
The utility business model and the future of computing services	Rappa, M.A	Article	167	2
Build to order supply chain management: a literature review and framework for development	Gunasekaran, A	Article	153	2
Developing business models for e-Business	Petrovic, O	Book	135	1
Research directions in requirements engineering	Cheng, B.H.C	Article	124	3
Use of electronic health records in US hospitals	Jha, A.K.	Article	120	2
From goals to aspects: discovering aspects from requirements goals models	Yu, Y	Article	113	3

**Figure I32 - Top Ten Articles by ‘Citation Count’ from the CAN Sample**

The initial citation network analysis shows the structure of the citation networks and the linkages between these early works in the Business models literature. The network shows connections between works, where authors who have cited one article have also linked to ideas in another.



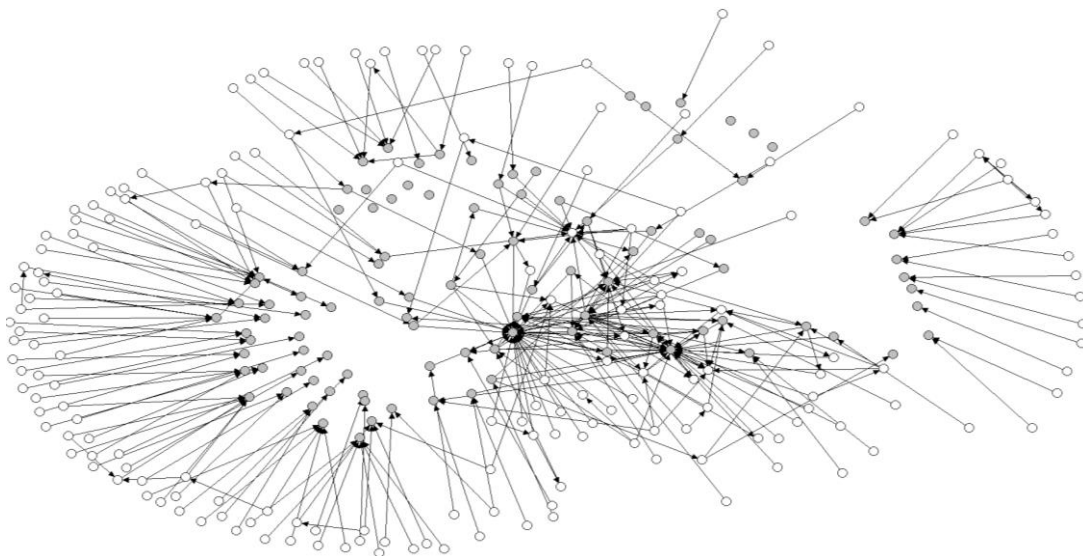
**Figure I33 - Initial Graph Generated From Netdraw**

However, the challenge with the above graph will obviously be the highest around the five seed articles. As these are used to search and generate the literature, the density of links between these literatures and the surrounding articles served to obfuscate the broader view of the field.

The next step in the process therefore is to delete the seed articles and the structures that connect them to the surrounding literature. This is easily done in Netdraw. What endures is the connections between the remaining parts of the literature. Here, despite the seed articles being deleted, there are still articles to which many other articles will refer. These can be seen to be “core” to the academic literature.

There are also other articles, so called “pendants” and “isolates” in graph terminology, which are then marooned. These are articles that, whilst having cited influential literature in a field, might not be considered core to that field as they are not cited by others in the field. This could be because they are academic cul-de-sacs, but also equally, it could just reflect the relative novelty of the articles that are yet to reach their audience.

The Netdraw software can automatically remove pendants and isolates, which was done after the picture below was produced (which shows isolates as individual dots).

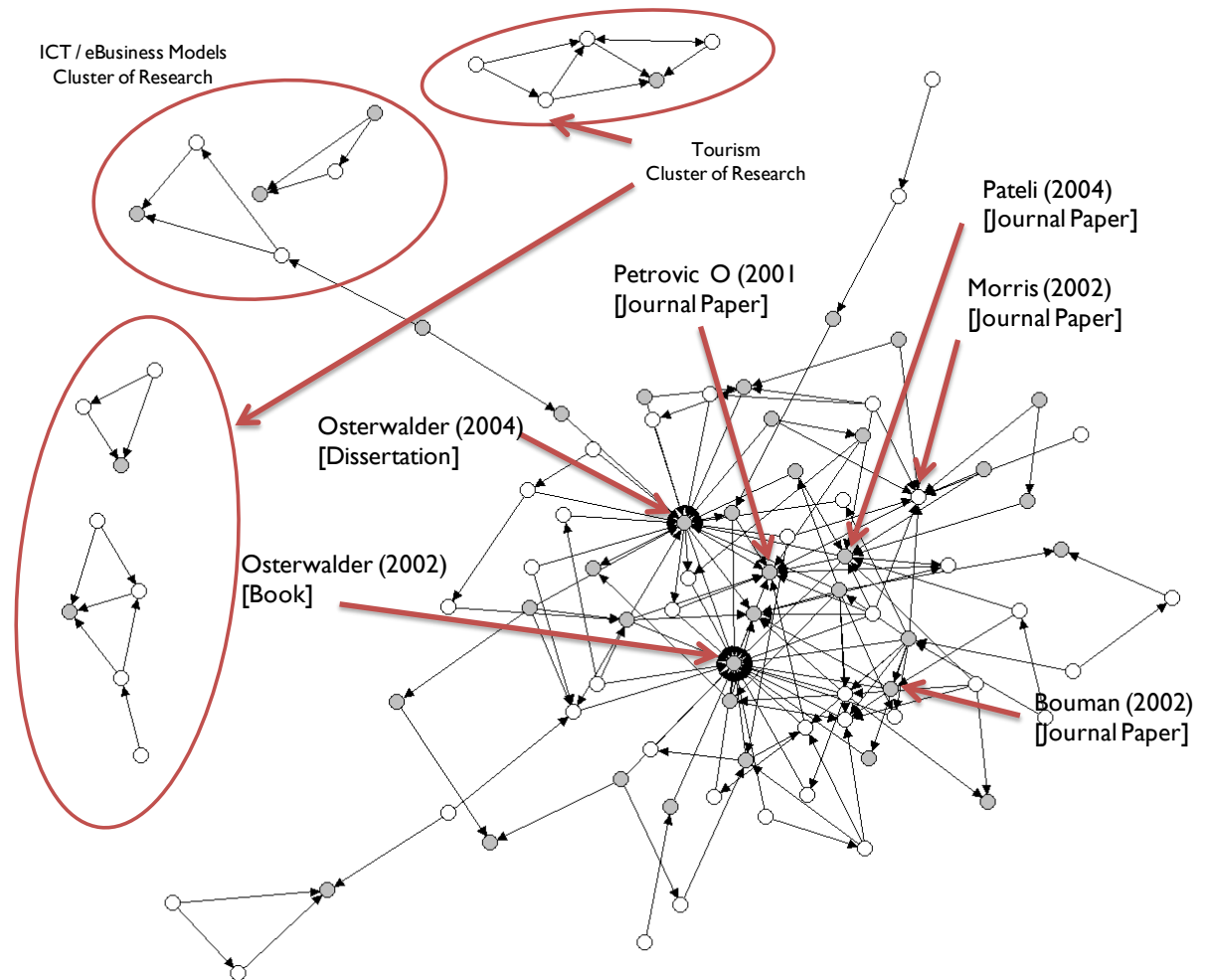


**Figure 134 - Citation Network with Seed Articles Removed**

The structures that are then left were re-organised into a Network diagram that was clearer. With the seed articles gone, a new “centre” of the network emerges from the remaining network connections. Furthermore, there are some ‘networks’ that form islands of research, articles that were connected by citations of the seed articles, but with these seeds removed, are no longer connected

by other linkages. For these, each individual node was interrogated using the Netdraw software in order to try to reveal common patterns about the articles that cited each other.

Several of the “Top Ten” cited articles disappeared once the pendants and isolates were removed.



**Figure 135 - Visualising the Linkages in the Business Model Literature**

## Appendix 3:

### Source Data

#### Primary Interviews Conducted By The Researcher

<b>Interviewee</b>	<b>Organisation</b>
<b>Steve Cousins</b>	Axon Automotive
<b>Bernadette Lally</b>	Office for Low Emission Vehicles
<b>Adam Cartwright</b>	Office for Low Emission Vehicles
<b>Ranbir Nota</b>	Office for Low Emission Vehicles
<b>John Lilly</b>	Dragon Electric Vehicles
<b>Warren Fauvel</b>	Fauvel Khan
<b>Hugo Spowers</b>	Riversimple
<b>Rosie Reeve</b>	Riversimple
<b>Andrew Haddon</b>	Elecscoot
<b>John Austin</b>	Future Transport Systems
<b>Liz Gray</b>	Future Transport Systems
<b>David Beeton</b>	One North East
<b>Brian Fothergill</b>	CENEX
<b>Colin Herron</b>	One North East
<b>Sean Long</b>	One North East
<b>Lucy Martin</b>	NAREC / Newcastle University
<b>Josey Wardle</b>	One North East
<b>Mike Simpson</b>	Ginetta
<b>Martin Ward</b>	CAP
<b>Denis Chick</b>	GM UK, Vauxhall
<b>Uta Deutsch</b>	GM UK, Vauxhall
<b>Peter Stevenson</b>	University of Glamorgan
<b>Alec Williams</b>	Zytek Automotive Ltd.
<b>John Jostins</b>	Microcab
<b>Courtenay Heading</b>	Bladon Jets
<b>Rebecca Trengrove</b>	Axeon (AG Holding Ltd)
<b>Viv Stephens</b>	CENEX
<b>Colin Mc Queen</b>	Allied Electric Vehicles
<b>Simon Dowson</b>	Delta Motorsport
<b>Nick Bolton</b>	Electric Corby
<b>Dan Jenkins</b>	Smiths Electric Vehicles
<b>Daniel Rogers</b>	Jaguar Land Rover
<b>Paul Faithfull</b>	Westfield Sportscars Ltd. / Potenza Technology Ltd.
<b>Robert Anderson</b>	Niche Vehicle Network
<b>Mark Lewis</b>	Gordon Murray Design
<b>Mark Tapscott</b>	Tesla Motors
<b>Chris Reeves</b>	MIRA
<b>Rob Anderson</b>	Niche Vehicle Network
<b>Tom Driscoll</b>	The Proving Factory
<b>Ian Mills</b>	Zytek Automotive

Table 34 - Table of Primary Interviews Conducted by the Researcher

## Secondary Analysis of Interviews Not Conducted By The Researcher

<b>Interviewee</b>	<b>Organisation</b>	<b>Reference</b>
<b>Gordon Murray</b>	Gordon Murray Design	(Owen, 2009)
<b>Paul Nelson</b>	Allied Electric Vehicles	(Sunderland, An interview with Allied Electric, 2010)
<b>Neil Butcher</b>	ARUP	(Sunderland, An interview with Arup, 2010)
<b>Michael Valvo</b>	Toyota	(Sunderland, An Interview with Toyota, 2009)
<b>Hugo Spowers</b>	Riversimple	(Sunderland, Interview with Riversimple, 2009)
<b>Chris Borroni Bird</b>	General Motors	(AWPresenter, 2010a)
<b>Andy Palmer</b>	Nissan Motor Company	(AWPresenter, 2010b)
<b>Rebecca Trengrove</b>	Axeon (AG Holding Ltd)	(AWPresenter, 2010c)
<b>Dr. Wolfgang Berhard</b>	Roland Berger Strategy Consultants	(AWPresenter, 2010d)
<b>Sandeep Kar</b>	Frost & Sullivan	(AWPresenter, 2011)
<b>Bill Parfitt</b>	GM UK, Vauxhall & Opel Ireland	(AWPresenter, 2010e)
<b>Ken Keir</b>	Honda	(English, 2012)

Table 35 - Table of Secondary Interviews Analysed by the Researcher

## Case Study Source Data

### TNC/MNC Vehicle Manufacturers

Manufacturer	Primary Interviews	Secondary Interviews	Notes
Aston Martin			
Honda			
Jaguar Land Rover	Interview with Daniel Rogers		
BMW (MINI, Rolls Royce)			
Nissan		Analysis of Interview with Andy Palmer (AWPresenter, 2010b)	Factory Visit to Sunderland
Toyota	Interview with Graham Smith	Interview with Michael Valvo	
Vauxhall	Interviews with Denis Chick, Uta Deutsch	Analysis of Interview with Chris Borroni Bird (AWPresenter, 2010a), Bill Parfitt (AWPresenter, 2010e)	Also spoke to Chris Borroni Bird at GM event.

Table 36 - Table Mapping Case Study Source Data for TNC/MNC Vehicle Manufacturers

### SME Vehicle Manufacturers

Manufacturer	Primary Interviews	Secondary Interviews	Notes
<b>Allied Electric Vehicles</b>	Interview with Colin Mc Queen	Paul Nelson, Allied Electric Managing Director. (Sunderland, An interview with Allied Electric, 2010)	Viewed Stand At CENEX LCV Show 2011
<b>Axon Automotive</b>	Interview with Steve Cousins		Factory Visit Viewed Stand At CENEX LCV Show 2013
<b>Bee Automobiles</b>	Interview with Stephen Voller, Warren Fauvel,	Analysis of Voller's appearance on 'Dragon's Den' (BBC, 2011)	Design House Visit
<b>Delta Motorsport</b>	Interview with Simon Dowson		Viewed Stand At CENEX LCV Show 2011
<b>Dragon Electric Vehicles</b>	Interview with John Lilly		Factory Visit
<b>Elecscoot</b>	Interview with Andrew Haddon		
<b>Electric Car Corporation</b>			Purely based on analysis of secondary data.
<b>Ginetta</b>	Interview with Mike Simpson		Factory Visit



<b>Gordon Murray Design</b>	Interview with Mark Lewis	Gordon Murray (Owen, 2009)
<b>Liberty Electric Vehicles</b>	Interview with Barry Shrier	
<b>Lightning Lotus</b>	Interview with Simon Wood	
<b>Morgan Modec</b>	Interview with Jevon Thurston-Thorpe	
<b>Riversimple</b>	Interview with Hugo Spowers	
<b>Smith Electric Vehicles</b>	Interview with Dan Jenkins	
<b>Westfield Sports Cars</b>	Interview with Paul Faithfull	

**Table 37 - Table Mapping Case Study Source Data for SME Vehicle Manufacturers**

## Appendix 4:

### Initial Interview Question Pool

#### General

How many people are employed by your organisation?

Can you supply a diagram of the organisational structure for your enterprise?

Can you explain the events leading up to the formation of the current enterprise and technology platform?

What was the catalyst for the development of your organisation and technology platform?

Can you explain what you see as key events in the organisation and technology platform's development?

What are the organisations key assets in terms of intellectual property, technology, and physical assets?

#### Activities

What are the **KEY ACTIVITIES** that your business undertakes?

What **KEY ACTIVITIES** do you need to undertake to deliver your **VALUE PROPOSITIONS**?

How do the **KEY ACTIVITIES** that your business plans to undertake differ from the conventional automotive industry, and how does this affect your business model?

How is innovation managed within the company?

To what degree is innovation generated internally vs. buying in external expertise?

What organisational knowledge is essential to the activities of the enterprise?

What capabilities does your firm possess that allows you to carry out the **KEY ACTIVITIES** of your business in an innovative way?

What past experience has shaped the way that your business intends to carry out its activities?

What activities will your business perform that rely on tacit knowledge within the company; that cannot be easily copied or duplicated?

How do the technologies and processes employed in prospective vehicle manufacture shape the configuration of the enterprises business model?

#### Partners

What partner organisations are key to your businesses success?

What suppliers are key to your business success?

Can you expand upon the relationship that your business has with it's suppliers?

What key resources will you acquire from partners?

What **KEY ACTIVITIES** do your partners perform?

What intellectual property do you purchase in from your suppliers?

What intellectual property do you share with / co-create with your suppliers?

To what extent will you require with state / public bodies to realise the business model?

Has your organisation formed any strategic alliances; and do you anticipate forming any in the future?

If you have, or anticipate forming a strategic alliance, what are the organisations needs that drive this alliance?

## Resources

What resources are essential for your business model to function?

How are resources managed within your business model?

What is the human resource required to realise the business model?

What resources are required for the manufacture of final products and how has this shaped the business model?

## Cost Structure

What are the most important costs inherent in your proposed business model?

Do you believe that any of the costs to which your business is (or will be) exposed will make your business model particularly vulnerable?

What Key Resources are most expensive?

What **KEY ACTIVITIES** are most expensive?

What scale does revenue generation need to reach for your business to become profitable?

What do you need to invest for your business to reach the level of scale where it can become profitable?

How will you manage the transition between producing vehicles on different volume scales?

What price point do you intend to market your vehicle / service at?

How did you arrive at the price point for your vehicle / service?

## Customer Relationships

Can you describe how you envisage the **CUSTOMER RELATIONSHIP** with your business over the lifecycle of the car? – from cradle to grave (or remanufacture)

What are the campaigns, strategies and tactics you will use to generate customer interest and leads?

## Customer Segments

What **CUSTOMER SEGMENTS** are you targeting your product at?

What **CUSTOMER SEGMENTS** are you not targeting your product at?

Is there a “regional dimension” to the **CUSTOMER SEGMENTS** that you are targeting your products at?

Does your vehicle / service sell into an existing market or are you creating a new market?

Do you believe that the market for your product already exists, or will it have to be created?

If you are trying to “create” a market for your vehicle, what strategy are you

### **Value Proposition**

How does your company improve on the **VALUE PROPOSITION** of the traditional automotive industry business model?

What supporting services / infrastructure are required to support the development of your business model?

How do you plan to deliver the associated services / infrastructure to support the development of your business model?

### **Channels**

What **CHANNELS** do you plan to use to distribute your product / service?

How does your businesses’ distribution model (**CHANNELS**) differ from the conventional automotive industry?

Do you believe that your distribution system (**CHANNELS**) offers environmental benefits over the “conventional automotive industry”?

Do you believe that your distribution system (**CHANNELS**) offers social benefits over the “conventional automotive industry”?

### **Revenue Streams**

What are the different **REVENUE STREAMS** through which your company will generate a profit?

How do you believe your business model’s **REVENUE STREAMS** differ from the conventional automotive industry?

What do you believe customers are willing to pay for the **VALUE PROPOSITION** that your company delivers and how does this differ from the **VALUE PROPOSITION** realised from conventional vehicles?

How do you believe your gross margin will compare to others in the automotive industry?

### **Concluding Questions**

How do you anticipate your business model evolving in the future?

Can you suggest anyone that I should speak to next?

## Appendix 5:

### Research Ethics Approval

#### Cardiff Business School Ethical Approval Form

#### PHD THESIS RESEARCH

(For guidance on how to complete this form, please see <http://www.cf.ac.uk/carbs/research/ethics.html>)

<b>For Office Use:</b>	<b>Ref</b>	<b>Meeting</b>
<b>Does your research involve human participants?</b> Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>		
If you have answered 'No' to this question you do not need to complete the rest of this form, otherwise please proceed to the next question		
<b>Does your research have any involvement with the NHS?</b> Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>		
If you have answered <b>Yes</b> to this question, then your project should firstly be submitted to the NHS National Research Ethics Service. Online applications are available on <a href="http://www.nres.npsa.nhs.uk/applicants/">http://www.nres.npsa.nhs.uk/applicants/</a> . It could be that you may have to deal directly with the NHS Ethics Service and bypass the Business School's Research Ethics Committee.		
<b>Name of Student:</b>	Gavin Harper	
<b>Student Number:</b>	0746116	
<b>Section:</b>	Marketing & Strategy	
<b>Email:</b>	harpergd@cf.ac.uk	
<b>Names of Supervisors:</b>	Dr. Peter Wells, Dr. Paul Nieuwenhuis, Prof. Ken Peattie	
<b>Supervisors' Email Addresses:</b>	<a href="mailto:wellspe@cf.ac.uk">wellspe@cf.ac.uk</a> , <a href="mailto:Nieuwenhuis@Cardiff.ac.uk">Nieuwenhuis@Cardiff.ac.uk</a> , <a href="mailto:Peattie@Cardiff.ac.uk">Peattie@Cardiff.ac.uk</a>	
<b>Title of Thesis:</b>	The Role of Business Model Innovation In Transitioning ULEVs to Market	
<b>Start and Estimated End Date of Research:</b>	<b>3+1 Studentship Starts September 2007, Estimated End July 2011 (Extended to March 2014)</b>	
<b>Fieldwork Starts April 2010 – Expected to Conclude October 2010 but some data collection will be ongoing.</b>		
<b>Please indicate any sources of funding for this research:</b>	ESRC 3+1 Ph.D Studentship	

#### ***I. Describe the Methodology to be applied in the research***

The research is largely qualitative in nature, collecting information about new entrants to the automotive industry manufacturing or proposing to manufacture zero emission vehicles. The research will largely consist of semi-structured interviews with key figures in this emerging marketplace. This will include those holding positions of responsibility within these companies and other stakeholders such as municipal authorities, funding bodies, those supplying infrastructure for zero emission vehicle e.t.c.

As part of the semi-structured interviews, it is intended to use visual prompts and a “business model representation tool” consisting of a laminated sheet which can be written on with wipe-clean markers, and onto which symbols and “post it notes” can be affixed. This is to enable participants to explain their ideas graphically, in a way that might lend itself better to diagrammatic representation than the linear prose that will be obtained from the interview.

**2. Describe the participant sample who will be contacted for this Research Project. You need to consider the number of participants, their age, gender, recruitment methods and exclusion/inclusion criteria**

The sample will be a non-probability selected sample. Key players within the firms of interest have been selected. A certain amount of convenience sampling will take place – the case studies rely heavily on access, availability and the willingness of those selected to take part. Following each interview, ‘snowball’ sampling will be used; with the interviewee providing further leads to pursue for data collection. A short list of potential case studies has been drawn up. In the event that access is hard to obtain or participants are unwilling to participate, there are a range of alternate case studies that can be pursued in order to get a representative sample of small, new entrant firms to the zero carbon automotive arena. It is not anticipated that any young people or vulnerable groups will be interviewed as part of this research.

**3. Describe the consent and participant information arrangements you will make, as well as the methods of debriefing. If you are conducting interviews, you must attach a copy of the consent form you will be using.**

All interviewees will be given a form outlining the ethical approval that has been granted for the research and outlining consent for the interviewees participation. They will also be given the option as to how they would like their data to be handled and processed.

It was regarded by the researcher that due to the intimate nature of the industry sector being examined, with a small group of companies, all of whom are aware to some extent of the actions of other market players, it would be hard to anonymise data in a meaningful manner.

However, to present context to the study it is important that these firms are mentioned by name as in many cases they are the only entrant pursuing certain technology pathways and business models. As it would be easy to identify the said firms from the level of detail presented in the case studies it was felt that anonymising the firms discussed in the case studies was unnecessary and would have little value. To this end, permission will be sought from the proprietors of the firms under examination and the case studies will comprise only of information that they are happy to enter the public domain.

Interviewees will be presented with a copy of the final transcript of the interview and allowed to make and clarifications or redactions.

**4. Please make a clear and concise statement of the ethical considerations raised by the research and how you intend to deal with them throughout the duration of the project**

The research will be dealing with a range of qualitative data, a portion of which may be considered commercially sensitive. Permission will be sought from the owners of the companies used as case studies to feature their organisation in the research, in all of the cases, the companies consist of very small, tightly integrated groups of people formulating a new business model.

It will be discussed with the proprietors of the organisations if there is any information that should be held confidential about the processes, technologies, models or methods used by these firms. Only information that they are happy to enter into the public domain will feature in the case studies of individual firms.

If there are additional points that are made that are of a confidential nature, but could contribute to the research in an anonymous capacity (with the participants informed consent), these may feed into general conclusions and findings of the research but will be documented in such a way that it is impossible to associate comments with either a firm examined under case-study or individual.

Any information communicated as “off the record”, will not be recorded, transcribed or held in any retrieval system, but may be communicated informally by interviewees to the researcher in order to help develop the researchers understanding of a situation or context.

**NB: Copies of your signed and approved Research Ethics Application Form together with accompanying documentation must be bound into your Dissertation or Thesis.**

**5. Please complete the following in relation to your research:**

		Yes	No	n/a
(a)	Will you describe the main details of the research process to participants in advance, so that they are informed about what to expect?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(b)	Will you tell participants that their participation is voluntary?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(c)	Will you obtain written consent for participation?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(d)	Will you tell participants that they may withdraw from the research at any time and for any reason?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(e)	If you are using a questionnaire, will you give participants the option of omitting questions they do not want to answer?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(f)	Will you tell participants that their data will be treated with full confidentiality and that, if published, it will not be identifiable as theirs?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(g)	Will you offer to send participants findings from the research (e.g. copies of publications arising from the research)?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**PLEASE NOTE:**

If you have ticked **No** to any of 5(a) to 5(g), please give an explanation on a separate sheet.

(Note: N/A = not applicable)

There is an obligation on the lead researcher to bring to the attention of Cardiff Business School Ethics Committee any issues with ethical implications not clearly covered by the above checklist.

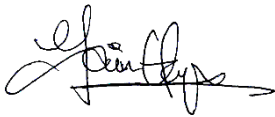
**Two copies of this form (and attachments) should be submitted to Ms Lainey Clayton, Room F09, Cardiff Business School.**

## Continuation Sheet

Points of clarification (f) –

- The companies examined will consent to being named in the work.
- The option of confidentiality will be given to participants.
- Due to the small (<10 employees) nature of the companies being examined, 'robust' confidentiality would be hard to attain, in most cases interviews will start with the CEO / founder of the company.
- Participants can elect for all or part of their interview to be treated as 'off the record'.
- Data will be identified to the case study in question.
- 'Commercially sensitive' data will be hard to anonymise in a robust way, so may be redacted from the final interview transcripts.

Signed



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Print Name: Gavin Harper

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Date:

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## Supervisor's Declaration

As the supervisor for this research I confirm that I believe that all research ethical issues have been dealt with in accordance with University policy and the research ethics guidelines of the relevant professional organisation.

Signed

(Primary supervisor)

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Print Name Prof. Peter Wells

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Date

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## Statement of Ethical Approval

This project has been considered using agreed School procedures and is now approved.

Signed

(Chair, School Research Ethics Committee)

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Print Name

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## Cardiff Business School Research Ethics Consent Form

This piece of research is being conducted as part of the Doctoral studies of Gavin D. J. Harper, it will be used in the pursuance of his PhD thesis and may result in additional further publications.

I understand that my participation in this project will involve a series of interview and discussion sittings, which, with my permission will be recorded. If at any time I wish to discuss anything of a confidential nature, I can request that the recording be stopped and any information imparted therein will be held confidential by the researcher.

The research will consist of a series of semi-structured interviews about business models for the realisation of zero carbon vehicles.

I understand that participation in this study is entirely voluntary and that I can withdraw from the study at any time without giving a reason.

I understand that I am free to ask any questions at any time. If for any reason I have second thoughts about my participation in this project, I am free to withdraw or discuss my concerns with Dr. Peter Wells ([wellspe@cf.ac.uk](mailto:wellspe@cf.ac.uk))

By signing this consent form you agree for your data to be used as part of ongoing doctoral research; you will be shown a copy of the transcripts of the interview and given the option to amend or redact any of your responses.

The information will be retained for the duration of the research. I understand that if I withdraw my consent I can ask for the information I have provided to be anonymised/deleted/destroyed in accordance with the Data Protection Act 1998.

I am happy for a transcript of my interview to be made for research purposes and kept for the duration of the research.

I, \_\_\_\_\_ (NAME) consent to participate in the study conducted by Gavin D. J. Harper MSc. MSc. BSc. (Hons) BEng. (Hons) MIET ([harpergd@cf.ac.uk](mailto:harpergd@cf.ac.uk)) of Cardiff Business School, Cardiff University, under the supervision of Dr. Peter Wells, Dr. Paul Nieuwenhuis & Prof. Ken Peattie.

Signed:

Date

## VITA

Gavin David James Harper (b.1986) holds BSc. (Hons.) Technology and BEng. (Hons.) Engineering from the Open University. His postgraduate study includes MSc. Architecture: Advanced Environmental & Energy Studies from the University of East London (a course delivered at the Centre for Alternative Technology), an MSc. Renewable Energy Systems Technology from Loughborough University's Centre for Renewable Energy Systems Technology and an MSc. Social Science Research Methods with a focus on Business and Management from Cardiff University. He is a Member of the Institute of Engineering and Technology. The initial research for this Ph.D was conducted under the ESRC's Centre for Business Relationships, Accountability, Sustainability & Society, which has now been incorporated into Cardiff University's Sustainable Places Research Institute. Gavin is a Director (Trustee) of the Centre for Alternative Technology.