3-31-2016

Strategies to Succeed in an Increasingly Technology-Based Environment: A Study of the Automotive Industry

Jose Geleilate
FIU, jgeleila@fiu.edu

DOI: 10.25148/etd.FIDC000219

Recommended Citation

Geleilate, Jose, "Strategies to Succeed in an Increasingly Technology-Based Environment: A Study of the Automotive Industry" (2016). *FIU Electronic Theses and Dissertations*. 2472.
https://digitalcommons.fiu.edu/etd/2472

FLORIDA INTERNATIONAL UNIVERSITY

Miami, Florida

STRATEGIES TO SUCCEED IN AN INCREASINGLY TECHNOLOGY-BASED ENVIRONMENT: A STUDY OF THE AUTOMOTIVE INDUSTRY

A dissertation submitted in partial fulfillment of

the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

BUSINESS ADMINISTRATION

by

José Mauricio Galli Geleilate

2016

To: Dean Jose Aldrich
College of Business

This dissertation, written by José Mauricio Galli Geleilate, and entitled Strategies to Succeed in an Increasingly Technology-Based Environment: A Study of the Automotive Industry, having been approved in respect to style and intellectual content, is referred to you for judgment.

We have read this dissertation and recommend that it be approved.

William Newburry

Sumit Kundu

Francisco Polidoro jr.

Weidong Xia

Ronaldo Parente, Major Professor

Date of Defense: March 31, 2016

The dissertation of José Mauricio Galli Geleilate is approved.

Dean Jose Aldrich
College of Business

Andrés G. Gil
Vice President for Research and Economic Development and
Dean of the University Graduate School

Florida International University, 2016

DEDICATION

I dedicate this dissertation firstly to God, who has given me life purpose and underserved grace, and also to my family, who has invested and encouraged me. I especially dedicate this work to my wife, without her dedication, hard work and unselfishness I would not be able to complete this task.

ACKNOWLEDGMENTS

I whish to thank God, my family, friends and committee members for the support, words of encouragement and wisdom shared with me. This work is the outcome of all input received from them. I am especially grateful to Dr. Ronaldo Parente, who has been very helpful and unselfishly caring along my PhD journey. I am grateful also to Dr. William Newburry and Dr. Sumit Kundu for their support and encouragement which made a great difference in my progress towards achieving my goals.

ABSTRACT OF THE DISSERTATION

STRATEGIES TO SUCCEED IN AN INCREASINGLY TECHNOLOGY-BASED ENVIRONMENT: A STUDY OF THE AUTOMOTIVE INDUSTRY

by

José Mauricio Galli Geleilate

Florida International University, 2016
Miami, Florida

Professor Ronaldo Parente, Major Professor

This dissertation investigates how firms embedded in an increasingly technology-based industry change their vertical integration and product development strategies in order to remain competitive and increase value capture. The first essay is a theoretical development integrating concepts of industry structure, organizational governance form and innovation in order to disentangle past research's disagreements and guide future studies. Firms are seen as proactive actors that also have their decisions strongly shaped by structural (architectural) factors. The second essay focus on analyzing how module suppliers achieve a sustained competitive advantage by increasing their focus on modular products and innovations as well as managing their vertically related operations. Results from the global automotive industry reveal that suppliers are capable of capturing more value from modules when investing in modular innovations, integrating manufacturing operations via M&As and strengthening downstream relationships through strategic alliances. Lastly, the third essay investigates the great complexities involved in the manufacture of automobiles. By acknowledging the important strategic implications of managing product failures to the overall performance and reputation of organizations, this essay attempts to fill a gap in the literature by investigating how increased product, process and supplier changes affect product failure rates, and how firms manage product redesigns and learning from past product failures to increase quality reputation. Results indicates that in complex product industries such as automotive, firms find it very difficult to increase product changes without incurring also in more product failures. The results also highlight the importance of strong supplier involvement and integration as a means to reduce product failure rates. This study also demonstrates that quality reputation is better assessed by consumers when manufacturers invest more in model redesigns. Yet, it shows that experience with voluntary recalls helps firms to learn how to improve their new products and increase quality reputation.

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

Firms facing pressures for more innovative products are not only in high-tech industries, as the development of new products and processes is a dynamic capability that confer firms from any industry increased competitive advantages (Helfat & Winter, 2011). Considering that innovation developments in one sector can have a profound impact in other industries, incumbent industry players are forced to reduce their product life cycle due to demand pressures and innovations stemming from seemingly unrelated business. Automotive suppliers have invested heavily on technological developments over the past twenty years as a result of OEMs' de-verticalization of their supply chain. Moreover, high-tech giants like Google and Apple are working on projects related to car manufacturing and other automotive components. This means that these firms are seeing an opportunity to utilize their capabilities to tap into market opportunities in which established automotive players cannot reach, and this might change even more automotive industry's supply chain architecture.

In this context, the focus of this research is to investigate what strategies firms embedded in increasingly dynamic environments have to pursuit in order to become more innovative, improve product quality and sustain value capture. Given the high level of competitiveness, complexity and ever increasing demand for innovative products in the automotive industry, I investigate how both suppliers and OEM develop strategies to remain competitive by upgrading their upstream and downstream operations. In the first essay, I propose that different industries have their own architectural structure (ranging from rigid to flexible) and this structure can influence how incumbent firms modify their boundaries in order to appropriate value from innovation. This essay lays the foundation for the other two empirical investigations in this dissertation. The second part of this dissertation focus on how suppliers can leverage value capture in their industry segment by integrating vertically both upstream and downstream operations. In the third essay, I investigate how OEMs manage product, process and supplier changes and its effects on recalls caused by OEM-related and supplier-related failures. Moreover, I also analyze how OEMs learn from voluntary and involuntary recalls and also from increased experience with model redesigns in order to attain greater brand quality reputation.

CHAPTER II

The Role of Industry Architecture on Firms' Integration Strategies of Value Appropriation from Innovation

The investigation of how firms set their boundaries and establish the division of labor within an industry has been an important topic in the strategic management literature (Cohen & Levin, 1989; Gereffi, Humphrey, & Sturgeon, 2005; Porter, 1996). Industry structures are the result of many endogenous (e.g. product life cycle and firm capabilities) and exogenous (e.g. regulations and access to resources) factors which can be overturned by innovation (Teece, 1996; Utterback & Suarez, 1993). Departing from transaction costs economics (TCE) and competence-based theories, scholars have developed theoretical frameworks to explain how product innovations can reshape the vertical integration of firms and industries (Jacobides, Knudsen, & Augier, 2006; Wolter & Veloso, 2008). Moreover, it has been found that firms' integration decisions are also intrinsically related to their selection of innovation activities, since firms may need to change their boundaries in order to appropriate value from innovation (Adner & Kapoor, 2010; Rothaermel, Hitt, & Jobe, 2006). Research on this interplay among innovation, industry structure and integration decisions has mainly focused on firm-led activities such as how firms focus on specific innovation types based on their level of integration (Kapoor, 2013), how upstream innovation can shape an industry sector (Bhaskarabhatla & Klepper, 2014) and how firms appropriate value from innovation using different vertical integration forms (Jacobides & Billinger, 2006; Rothaermel et al., 2006).

However, little attention has been drawn to how industry structure and firm organizational forms shape innovation endeavors (Kapoor & Lee, 2013; Luo, Baldwin, Whitney, & Magee, 2012). It is known that industry structure or industry “architectures”, which are defined as the template that determines the division labor or “who does what” and the “rules and roles” in an industry (Jacobides, Knudsen, & Augier, 2006) will also play a key role in determining how firms’ appropriate value from innovation (Jacobides, MacDuffie, & Tae, 2012) and how firms develop their capabilities (Jacobides & Winter, 2012). Since industry architectures are defined by how firms organize production within a value chain, this means that industries differ in their architectures and also that these architectures are susceptible to change. In this case, the investigation of how different industry architectures influence how firms modify their boundaries to appropriate value from innovation can provide important insights and advance scholarly understanding on industry-related effects on innovation. This leads us to the following research questions: How industry architectures are established? Yet, how industry architectures influence firms’ integration decisions in order to appropriate value from innovation?

From an institutional and sociological perspective, scholars have pointed out that firms’ and institutional agents’ behavior determine the structure of an industry, which in turn creates an environment that has its own particular properties (Geels, 2004). This investigation is of great importance to the understanding of how different industry architectures influence firms’ innovation and integration strategies. It can also shed light on why past research on firm integration decisions are often in disagreement (Harrigan, 1984; Lafontaine & Slade, 2010). I focus on product manufacturing industries and make a distinction between firms in terms of their position in the value chain. Thus, I differentiate suppliers and lead firms (assemblers) given their different roles and proximity to final product users since value chain positioning has an important influence on vertical integration decisions and innovation activities (Kapoor & Lee, 2013).

In order to establish the theoretical background, I start the rationale describing how transaction costs and resource-capabilities theories are linked with innovation and industries' organizational governance form (industry architecture), which in turn has a recursive effect on firms' strategies of value appropriation. I focus on complex product manufacturing industries composed by OEMs (assemblers) and their suppliers and develop propositions regarding which organizational governance form and strategies firms should follow. Specifically, I note that industries vary from rigid to flexible architectures, and this structure affects how assemblers and suppliers develop their integration strategies to appropriate more value from their innovative endeavors. Following recent theoretical developments on value creation and value appropriation from innovation (Adner & Kapoor, 2010; Kapoor, 2013) I note the difference between different players and their location within the value chain as an important element that differentiate how firms should manage their boundaries in order to leverage and sustain competitive advantages from innovation.

THEORY DEVELOPMENT

Vertical Structure Determinants

The study of how firms organize their production factors dates back to Adam Smith (1776) in his assessments on division of labor and productivity. Over the twentieth century, scholars have advanced the understanding of firms' boundary choices as industry evolution and technological shifts provided evidence that concepts such as transactions costs, scale returns and opportunistic behavior have an important role in shaping firms' organizational governance form and industry structures (Conner, 1991; Madhok, 2002). Early studies on why firms exist and what determines their scale and scope have emphasized mainly the production decisions that maximize profits in competitive environments (Coase, 1937; Stigler, 1951; Williamson, 1971, 1975). Thus, studies on industrial organizations have focused on how firms conduct their activities in an static industry structure characterized by imperfect competition (Bain, 1951; Nelson, 1994; Porter, 1981). According to the industrial organization (IO) perspective, the industry structure is viewed as the result of economic and technical aspects (e.g. entry barriers, imitation and bargaining power) where competition takes place (Bain, 1951; Porter, 1981). Drawing on mainstream theories of competitive strategy and economics, the study of how firms' integration decisions shape industry structures has largely focused on a transaction costs or firm capabilities perspective (Klepper, 1997; Stigler, 1951). However, industrial organization scholars have mainly focused on the nature of competition in an industry (Porter, 1981; Rumelt, 1991) and there is still a dearth of research on the determinants of vertical industry governance forms and why they differ (Gereffi et al., 2005; Luo et al., 2012).

Transaction costs economics (TCE) theorists posit that a firm will change its vertical scope of production based on the assessment of costs involved in producing in house and the liabilities of contracting from suppliers (Coase, 1937; Williamson, 1971, 1975). Specifically in cases where products or services have high levels of customization and where production requires increased coordination, firms will tend to internalize production (Fine, 1998; Langlois & Robertson, 2002). Thus, transactions costs are intra and inter-firm costs based on the uncertainty, specificity and frequency of an economic decision and firms will prefer to vertically integrate production when one or more of these aspects increase (Hennart, 1993; Williamson, 1971).

On the other hand, the resource-capabilities literature stream argues that firms will get specialized in capabilities that can confer them competitive advantages (Richardson, 1972), which in turn will define their boundary decisions (Jacobides & Winter, 2005; Teece, 1996; Wernerfelt, 1984). From this perspective, scholars have found that although firms will change their boundaries in order to reduce transaction costs, organizational capabilities are also as important in shaping their vertical integration form (Jacobides & Winter, 2012; Madhok, 2002). Madhok (1996) argued that TCE is an "inadequate and shallow basis theory of the firm" and proposes that the organizational capabilities view of the firm is the missing link to the understanding of firms' boundary and governance decisions. In this case, firms are seen as not only a bundle of transactions but also as a bundle of knowledge and its underlying processes (Madhok, 1996). Thus, scholars more recently have integrated TCE and capabilities arguments in order to explain the various firm governance forms existent (Jacobides & Winter, 2012; Leiblein, 2003; Madhok, 2002).

Jacobides and Winter (2005) propose a systemic view of firms' vertical integration choice based on the dynamic nature of firm capabilities and changes in transaction costs over time. The authors point out that transaction costs and firm capabilities co-evolve, interact and shape the firms' *menu* of vertical scope alternatives. More recently, Jacobides and Winter (2012) increment the integrative view of TCE and capabilities perspective by highlighting the role of industry architecture in shaping firms' capabilities and competitive dynamics. In this case, the authors demonstrate that there's a recursive feedback between firms' capabilities evolution and industry structure. This observation is consistent with past research observations that industrial structures tend to migrate from vertical to more horizontal governance forms due to a number of factors such as increased scale returns, modular production and development of firm capabilities and technological advancements (Baldwin & Clark, 2000; Gereffi, 1999; Jacobides & Winter, 2012; Stigler, 1951). On the other hand, it is known also that other factors such as more radical or systemic innovations will increase the need for more integrated operations in a value chain (Langlois & Robertson, 2002).

Therefore, alongside to firm capabilities and transaction costs, innovation developments play an important role on industries' vertical integration (Kapoor, 2013; Wolter & Veloso, 2008). For example, Wolter and Veloso (2008) noted that industries' vertical integration form may change as a result of technological shocks. Specifically in the cases of more radical, architectural or modular exogenous innovations, firms playing the role of system integrators will have more incentives to vertically integrate their operations and the degree of integration of an industry will increase. Moreover, Firms not only may change their boundaries as a response to exogenous innovations but they also might have to change their vertical scope in order to appropriate value from their own innovation developments (Jacobides et al., 2006; Santos & Eisenhardt, 2009; Teece, 1986). David Teece's (1986) landmark article points out that innovating firms often fail to obtain significant economic returns from an innovation due to a lack of good positioning regarding complementary assets as well as poor understanding of appropriability regimes and bad integration decisions. Building on Teece's propositions, Jacobides et al., (2006) developed a framework showing that complementary assets mobility and degree of complementarity jointly affect firms’ integration decision to increase returns from innovation. The authors also define the concept of industry architecture, established as the “sector-wide the templates that circumscribe the division of labor” providing the rules of “who can do what” (labor division) and “who gets what” (value appropriation).

However, it is important to note that different industry architectures have different configurations, which in turn will have a specific impact on incumbent firms’ behavior (Langlois & Robertson, 1992; Malerba & Orsenigo, 2000). This research attempts to fulfill this gap by proposing that different industry architectures have particular characteristics that enhance or hamper incumbent firms’ capacity to appropriate value from product innovation. Moreover, I note that a firm’s position in the value chain is also an important factor that determines which upstream or downstream boundary decision it must consider in order to increase its revenues from innovative product developments (Kapoor & Lee, 2013). Next, I delve into the distinct types of industry architectures and their effects on incumbent firms and develop propositions regarding which (dis)integration endeavors suppliers or assemblers should invest in order to appropriate more value from their product innovations.

Industry Architecture and Innovation

Before describing the mechanisms in which industry architectures will determine how firms change their boundaries to increase value appropriation from innovation, I briefly describe the main propositions and findings from past research regarding the relationship between industry structure and innovation. Early thoughts on how industry and firms should be organized in order to produce optimal economic performance have mainly focused on the role of technological progress, firm size and market concentration (Cohen & Levin, 1989). Schumpeter (1942) viewed the large firm operating in a concentrated market as the main force of economic and innovative development due to its superior technological capacities and economies of scale. Inspired on Schumpeter's work, a great deal of empirical investigations focused the role of firm size and market concentration as drivers of innovation, however, little agreement was found (Cohen & Levin, 1989). The idea that large firms were the primary drivers of innovation was also endorsed by Chandler's (1977) view of the "visible hand of management" which proposed that large enterprises, due to their production capacity and efficiency, are the main source of innovation and economic progress. Thus, internal capabilities should be enhanced via integrated production where a centralized and vertical organization form should bring increased economic returns and innovation output (Chandler, 1977; Lazonick, 1993; Schumpeter, 1942). On the other hand, Alfred Marshall's work highlighted the interactions among firms within an industry and the price system as important generators of external economies, suggesting that more horizontal industry structures could also function as drivers of innovation and economic growth (Langlois, 1992; Marshall, 1920).

Considering both firm-led and market-led forces driving innovation within an industry, scholars have noted that innovation development patterns industries' degree of vertical integration are intrinsically related (Langlois & Robertson, 1992; Malerba & Orsenigo, 1996). Although past research has pointed out innovation as a key driver of industries' organizational form change (Wolter & Veloso, 2008), the literature is still incipient on the investigation of how and why industries change their vertical scope over time (Jacobides et al., 2012; Luo et al., 2012; Malerba & Orsenigo, 1996). Previous work has mainly focused on industry differences in terms of technological and competitiveness patterns and its modifications over time, paying little attention to industries' organizational governance forms. For example, Nelson and Winter (1982) labeled industries in terms of its patterns of innovation accordingly to Schumpeter's perspective of "creative destruction" and "creative accumulation". A Schumpeter Mark I industry pattern is characterized by creative destructive innovations introduced by firms that did not innovate before. This creates a context of technological ease of entry and increased entrepreneurial activity which spurs continuous disruptive activities (Breschi, Malerba, & Orsenigo, 2000; Nelson & Winter, 1982). A Schumpeter Mark II industry pattern is one of more stable innovation ratios and more established hierarchies of innovators. These industries have an innovation pattern based on "creative accumulation" and are characterized by the prevalence of large firms and entry barriers to new innovators (Breschi et al., 2000; Nelson & Winter, 1982).

Cohen and Levin (1989) argue that research on Schumpeter's hypothesis are "pervaded by methodological difficulties", and that inter-industry differences of innovation patterns are the result of three major factors. 1) The structure of demand, characterized by price elasticity, technology-push or demand-pull forces. 2) Technological opportunity, regarded as the set of possibilities or easiness in transforming investments into innovation. And 3) appropriability conditions, which is the capacity to protect and keep proprietary one's innovative endeavors. Thus, empirical studies have confirmed, with some restrictions, the aforementioned Schumpeterian industry patterns of innovation (Breschi et al., 2000; Malerba & Orsenigo, 1995, 1996; Nelson & Wolff, 1997; Peneder, 2010). For example, drawing on Nelson and Winter's (1982) technological regime factors, Malerba and Orzenigo (1993) demonstrate that technological opportunities, appropriability, cumulativeness of technical advances and knowledge base properties[1] will define the technological regime of an industry. They found that Schumpeter Mark I industries have high opportunity and low appropriability and cumulativeness, while Schumpeter Mark II industries have high levels of appropriability, opportunity and cumulativeness conditions.

The investigations on the different factors shaping industries' technological regimes was also used in the context of industry life cycles (Abernathy & Utterback, 1978; Utterback & Suarez, 1993), industry's structural evolution (Malerba & Orsenigo, 1996) and evolutionary economics (Dosi & Nelson, 1994; Nelson & Winter, 1982). Utterback and Suarez (1991) argued that each industry has its own technology evolution, which shapes the very industy's organizational structure. In the initial stage, right after the product invention, the market is ill-defined and there is a high level of uncertainty regarding the technology and market response. The market is rapdly populated by small vertically integrated firms competing for market share. In a second stage, a dominant product design emerges and production processes become more standardized, which in turn creates transaction patterns within the industry. In this stage, the focus migrates to process innovations and large scale production while products still posess an integral architecture. Depending on the complexity of the manufactured product, co-specialized firms assume an important role in the production process as the industry starts to vertically unbundle and innovative endeavors become largely incremental. The pattern of transactions between firms and specialization define the division of labor of an industry and, once the industry

---

[1] Malerba and Orzenigo (1993, 1996) define innovation opportunity as the ease of innovation given the amount of investment needed. Appropriability conditions reflects the protection of a given innovation. Cumulativeness is based on the idea that new innovations rely on previous innovative developments, while the knowledge base can be primarily tacit and local or codified and universal.

architecture is established, industry participants will also be impacted by the institutionalization (Meyer & Rowan, 1977) and rigidities (Leonard-Barton, 1992) created over time. This process is repeated when “competence destroying” or “radical” innovations are introduced, which incurs in discuntinuties and the rise and fall of firms (Afuah & Utterback, 1997).

Fine (1998) puts the industry evolution pattern into a double-helix perspective, arguing that industry clockspeed (rate of change in the life cycles of products within an industry) has a key role in determining how fast (dis)integration will occur. In this case, both patterns of vertical integration and disintegration occur in a cyclical and sequential manner, driven by the aforementioned forces (see figure 1).

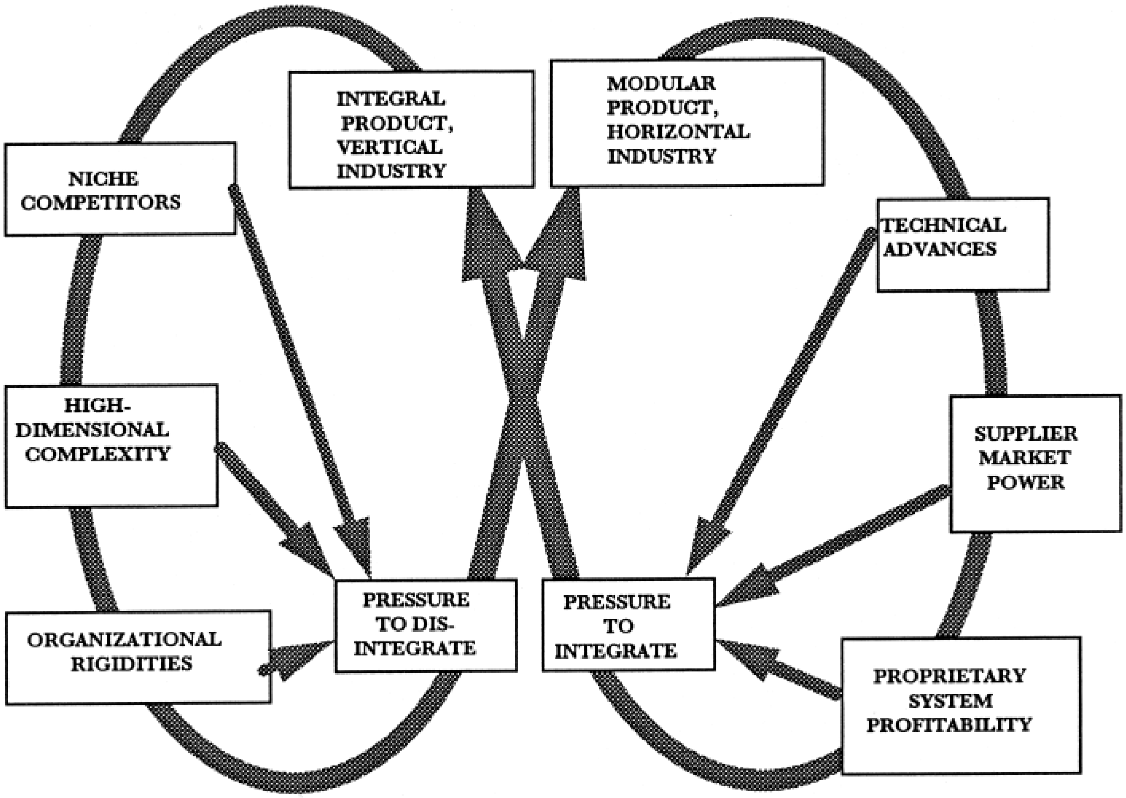
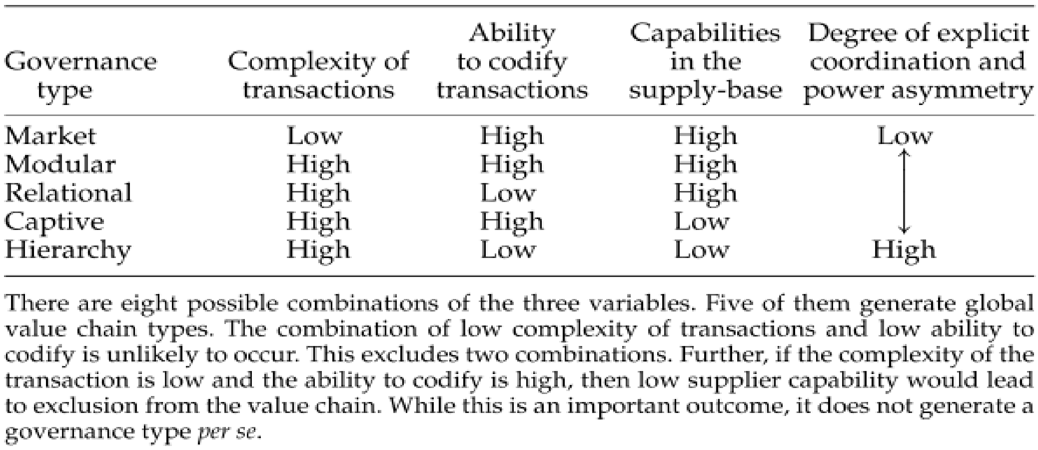


Figure 1: The double-helix model of industry integration (Fine, 1998)

Although these models of industry evolution have been useful to explain patterns of vertical integration in the automotive and computers' industry, in some other cases (microprocessors and semiconductors) this patterns is not so straighfoward (Cohen & Levin, 1989; Kapoor, 2013). Noticing that industries have different technological regimes and evolutionary paths (Breschi et al., 2000), scholars have started to investigate why and how industries differ in their organizational governance forms.

The literature on global value chains (GVC) is the one that most inform about why industries have different vertical organizational forms (Gereffi et al., 2005; Gereffi, 1999; Sturgeon, Biesebroeck, & Gereffi, 2008), but interestingly it has not been linked with mainstream strategy research (Jacobides et al., 2012). Gereffi et al., (2005) developed a theoretical framework explaining how production is organized within a global value chain, and how these value chains change. The authors propose that global value chains are shaped by (1) the complexity of transactions, (2) the ability of firms to codify transactions, and (3) the capabilities of the supply-base, and a specific combination of these factors represent a particular industry governance form (see figure 2).



Governance type	Complexity of transactions	Ability to codify transactions	Capabilities in the supply-base	Degree of explicit coordination and power asymmetry
Market	Low	High	High	Low ↑
Modular	High	High	High	
Relational	High	Low	High	
Captive	High	High	Low	↓
Hierarchy	High	Low	Low	High

There are eight possible combinations of the three variables. Five of them generate global value chain types. The combination of low complexity of transactions and low ability to codify is unlikely to occur. This excludes two combinations. Further, if the complexity of the transaction is low and the ability to codify is high, then low supplier capability would lead to exclusion from the value chain. While this is an important outcome, it does not generate a governance type *per se*.

Figure 2 – Industry governance configurations (Gereffi et al., 2005).

These three factors are drawn from the transaction costs and resource-capabilities literature previously mentioned, and are determined by product-related complexities which are related to the industry life cycle as well. First, the complexity of transactions in an industry is related to the type of information and knowledge transferred between firms with regards product and process specifications. Second, the codifiability of transactions captures how difficult or complicated it is to transfer knowledge and information between firms, while the supply-base capabilities factor highlights how prepared suppliers are to meet downstream requirements (Gereffi et al., 2005). Gereffi's et al., (2005) framework has been highly cited in the literature and its typologies (hierarchy, captive, relational, modular and market) have been applied to explain empirical cases (Gibbon, Bair, & Ponte, 2009; Nadvi, 2008).

Considering that industry architectures (IA) are referred as the patterns of labor and value division within an industry (Jacobides et al., 2006), I link Gereffi's et al., (2005) work on GVCs' governance forms with some of the important factors raised by the literature on industry's technological regime and evolution (Fine, 1998; Langlois & Robertson, 1992; Utterback & Suarez, 1993) and modularization (Baldwin & Clark, 1997; MacDuffie, 2013; Sanchez & Mahoney, 1996; Sturgeon, 2002) in order to better define the drivers of IA forms.

First, IAs are structured around the rate of change in product life cycles, i.e. industry clockspeed, which directly determines the flexibility of products' dominant designs and shapes the number of participating firms throughout the value chain and their profitability (Afuah & Utterback, 1997; Fine, 1998). Product and process complexities and technological advancements play a key role in shaping industries' clockspeed. In this context, modularization emerges as fundamental concept used to improve the efficiency of transactions between firms (Baldwin & Clark, 1997; MacDuffie, 2013; Sanchez & Mahoney, 1996). On Gereffi's et al., (2005) framework, the complexity and codifiability of transactions are considered key elements determining GVCs organizational form. These two factors can be put together under the concept of modular production implementation within an industry. Since modularization is the result of standard procedures, processes and interfaces, the codifiability of transactions needs to be high in order to modular production systems function properly. There are four possible combinations between complexity and codifiability of transactions. Since low complexity and low codifiability are mutually exclusive, three combinations remain (Gereffi et al., 2005). In this case, what tips the scale between more or less modular production/adoption in an industry is the codifiability of transactions. In industries where the codifiability is high, modular production will prevail, while in cases of high complexity and low codifiability the industry will have lower levels of modular production. Thus, modularity is not a particular product feature and needs to be developed throughout the value chain (Baldwin & Clark, 2000; Sturgeon, 2002), which creates specific roles and patterns of interactions, thus shaping the industry architecture.

In line with Gereffi's et al., (2005) framework, I also consider supplier-base capabilities of production as a determinant of industry architectures. The supplier base can be configured in different ways, ranging from industries with a composition of strong and well established players to industries with resource-dependent (captive) suppliers. While suppliers in some cases can build architectural advantages such as being in a bottleneck position (Baldwin & Clark, 1997; Jacobides et al., 2006), in more rigid structures suppliers have downstream resource dependencies. In sum, industry architectures are the result of (1) industry clockspeed, (2) modular production, and (3) the capabilities of the supply-base. Since GVCs have different governance forms, I propose that industrial architectures also have different configurations. From this perspective, an industry architecture represents the very governance form of a value chain[2]. Thus, Gereffi's et al., (2005) proposed generic governance forms are seen as examples of IAs at different levels of flexibility. In the same way that GVCs evolve and change, IAs are also dynamic and can have their structure shaped by internal and external factors, and should be seen as ranging in a continuum, from more rigid to more flexible architectures.

Ultimately, as a result of the type of relationship between lead firms (assemblers) and suppliers formed in an industry architecture, power asymmetries are formed and have a particular effect on value appropriation (Gereffi et al., 2005). Moreover, industry architectures are also related to the conditions affecting firms' profitability in a sector. Jacobides et al., (2006) highlight the importance of complementary assets mobility and degree of complementarity within an industry architecture in shaping the profitability of firms in different parts of the value chain. Therefore, each IA has its own set of factors limiting firms' value appropriation. The influences of established industries' configurations on firms' integration strategies and innovation is assumed as endogenously co-determined by the literature (Breschi et al., 2000; Nelson & Winter, 1982). More

---

[2] Value chain here is seen as the a value-added chain is "the process by which technology is combined with material and labor inputs, and then processed inputs are assembled, marketed, and distributed" (Kogut, 1985).

recently, scholars started to investigate the case when a firm’s boundary choices determine its innovation activities (Fixson & Park, 2008; Kapoor & Adner, 2012; Kapoor & Lee, 2013), however, there’s still a lack of research on how industry architectures influence firms’ alternatives of vertical integration and value appropriation from innovation.

In the realm of complex product manufacturing industries, there are two main players with distinct roles, product assemblers (which can take the role of system integrators) and suppliers. Thus, integration strategies vary not only due to architectural conditions but also based on the firm’s location in the value chain. Adner and Kapoor (2010) propose that vertical integration is more useful when a given technology is mature, since integrated operations mitigate contractual hazards but not necessarily technological challenges. The authors also highlight that past research has neglected the location of activities along the value chain, and demonstrate that upstream and downstream challenges in the value chain have different impact on value appropriation of suppliers in comparison to lead firms. From this perspective, I propose a theoretical model to assess how firms should manage their boundaries in order to appropriate value from innovation depending on location within the value chain which is also shaped by the industry architecture. Specifically, lead firms (firms that sell to the final consumer) are analyzed in this study as having distinct patterns of behavior and boundary spanning options in comparison to their suppliers. This distinction is very important to theory development since innovation dependencies have been largely putted aside in the literature (Adner & Kapoor, 2010).

Finally, I argue a firms’ integration strategies of value appropriation from innovation will depend also on the innovation type developed in house. Complementing Wolter and Veloso (2008) argument that firms change their boundaries in reaction to exogenous technological shocks, I propose that in-house innovation developments are not only an outcome of the firm’s existent vertical integration configuration (Kapoor, 2013) but also a determinant of its future boundary spanning decisions. Since incremental innovations involve lower codification and coordination costs with suppliers in contrast to more radical innovations (Benner & Tushman, 2002; Henderson & Clark, 1990), it is important to consider the particular effect of incremental or radical innovation on firms’ vertical integration choice. Thus, the proposed framework is composed by three main factors: industry architecture flexibility, firm role in the supply chain and innovation type, and it is seen from the perspective of an innovating firm that is the first to introduce a new product/technology to the market.

THEORETICAL MODEL AND PROPOSITIONS

Incremental innovation and integration strategies

It is quite well known that being the first to introduce a new product/technology to the market is not a guarantee of value appropriation success or sustainable competitive advantage (Jacobides & Billinger, 2006; Pisano, 2015; Teece, 1986). The seminal work of Teece (1986) points out that managing complementary assets and manufacturing capabilities is crucial to value appropriation from innovation. Therefore, it is clear that both upstream and downstream activities and how a firm manage its boundaries around these operations are the main determinants of innovation success in the market.

The starting point to understand which integration strategy firms should pursue in order to appropriate value from innovation is the assessment of industry architecture. In industrial contexts characterized by flexible architectures, a faster clockspeed is sustained by firms' increased capabilities to develop new products and work via market or modular production systems (Gereffi et al., 2005). Lead firms usually have low switching costs and an available pool of competitive suppliers. Downstream markets have a diverse and large number of complementary assets but on the other hand, powerful competitors drive margins down and competitive advantages are difficult to be sustained. In this context, a lead firm developing an incremental innovation will incur in low adaptation costs with its supplier base to manufacture the new product. Thus, upstream integration incentives will be low to disintegrated lead firms, since they can count on a flexible supply chain, while more integrated firms will also have no incentives to disintegrate. Wolter and Veloso (2008) confirm this prediction by arguing that when transaction (coordination) costs are low and supplier capabilities are high, firms will not have incentives to change their upstream mode of operation.

When it comes to vertical integration in downstream operations, the literature is very incipient in the study of how innovation and downstream operations interact. Adner and Kapoor (2010) point out that when a focal firm develops an innovative product, innovation challenges faced by complementary (downstream) business have a negative effect on focal firms' value creation. In the case of an incremental innovation, although it do not imposes technological challenges to suppliers, lead firms need to ensure that the new products keep its compatibility with complementary assets (Teece, 1986). Pisano (2015) argues that firms need to be coherent in their innovation strategies, which means that new product developments need to be aligned with the right set of upstream and downstream capabilities. The author demonstrates that incremental innovations that leverage existing business models need to be surrounded by complementary assets, which in turn can become a source of competitive advantage.

One strategy pursued by lead firms to retain more value from incremental innovations has been to make asset investments in complementary product/service firms. Jacobides et al., (2006) point out that when firms have products with high levels of complementarity (how much an innovation can be coupled with/needs complementary assets) and encounter also increased factor mobility (number of alternatives), these firms can “rule without assets” by investing in complementary assets that will appreciate with innovation. However, the literature points out that mergers and acquisitions have high indices of failure due many reasons such as integration issues and understanding of the new business (Christensen, Alton, Rising, & Waldeck, 2011). Googles’ acquisition of Motorola for US12.4 billion and sale for US2.35 billion to Lenovo two years later serves as an example that firms placed at intermediate levels within the value chain struggle to manage downstream business in highly competitive environments. It is worth noticing that Googles’ press-release statement “[that] *the smartphone market is super competitive, and to thrive, it helps to be all-in when it comes to making mobile devices*” reveals that full ownership of downstream complementary business may require skills and levels of commitment that are too costly for the investing firm, which makes asset and intellectual property (IP) investments a better alternative (Google retained its intellectual property assets and licensed the utilization of over 17.000 patents). Stuckey and White (1993) have pointed out that “*managers sometimes over-integrate because they fail to consider the rich array of quasi-integration strategies*”. On a related note, McGuire and Staelin (1983) found in an econometric study that firms will prefer to vertically integrate downstream only when competition in this level is low. Quasi-integration investments such as joint ventures, strategic alliances and minority stakes are particularly useful for a firm to exchange knowledge having a certain type of control and maintaining a formal trade relationship. Since downstream vertical integration in highly competitive environments is risky and costly, both suppliers and lead firms embedded in a flexible industry architecture would be better able to leverage their value appropriation from incremental innovations through downstream asset investments of complementary assets instead of getting into merges and acquisitions. Thus, I propose:

> *Proposition 1: Lead firms and suppliers in a flexible industry architecture will appropriate more value from incremental innovations by investing in quasi-integration strategies of downstream complementary assets instead of acquiring downstream business.*

In more rigid industry structures firms encounter greater levels of resource dependencies and power asymmetries. That is because there is a high level of product complexity, difficulties in codifying knowledge and the presence of lead firms that keep the role of system integrators and exert great bargaining power over its suppliers base (Gereffi et al., 2005; Jacobides et al., 2012). These industries are characterized by increased levels of vertical integration, and innovation developments usually occur within a close buyer-supplier relationship. In the case of incremental innovations, scholars propose that changing the vertical integration structure downstream may not be needed since incremental developments incur in low transaction and coordination costs (Wolter &

Veloso, 2008). However, it is known that rigid industry structures such as the aircraft and automotive are characterized by high levels product integration and tacit knowledge difficulties which in turn create pressures for integration. The literature has shown that even small product changes can create systemic problems due to the many interactions between parts (Kotabe et al., 2007) and that closer buyer-supplier relationships are important determinants of efficiency gains (H. J. Dyer & Hatch, 2006; J. H. Dyer & Nobeoka, 2000).

Thus, although vertical disintegration should appear as a more efficient way of production according to the industry life cycle perspective (Afuah & Utterback, 1997), rigid industry architectures characterized by high levels of product complexity and interdependency (asset specificity) will remain vertically integrated and innovators that are better capable of managing integrated operations are rewarded. Even in the case of outsourcing trends such as the one faced by the automotive industry in the 1990s, firms that kept a relational linkage with their suppliers (e.g. Japanese assemblers and suppliers) instead of utilizing a market approach (price-based relationships) were found to be more successful over time (Sturgeon, Memedovic, Biesebroeck, & Gereffi, 2009). The great number of western auto suppliers' bankruptcies occurred from 1999 to 2008 (none of those bankruptcies were of Japanese firms) indicates that US and European automakers price-based and disintegrated upstream strategy has not been sustainable. In the case of Boeing, which increased its outsourcing from 35-50% in the production of the 737 model to 70% in the 787 model, problems with integration and schedule delays also highlight the need of integrated buyer-supplier interactions (Tang & Zimmerman, 2009). This also indicates that in rigid industry architectures, value appropriation from incremental innovations will be achieved through increased levels of buyer-supplier integration, thus complementing the view that although incremental innovations do not increase transaction costs (Wolter & Veloso, 2008) it can require increased levels of integration.

Lead firms investing in a close relationship with suppliers via minority stake and alliances have been found to reap increased innovation, performance and efficiency of operation (J. H. Dyer & Nobeoka, 2000; Jean, Sinkovics, & Hiebaum, 2014; Kotabe, Martin, & Domoto, 2003). Therefore, suppliers also benefit from greater downstream integration via alliances and partnerships with assemblers (Kotabe et al., 2003; Lakshman & Parente, 2007). Additionally, investing in the acquisition of complementary assets can be particularly important in the case of suppliers in rigid structures. Suppliers having high downstream resource dependencies find themselves in a very risky position. Thus, suppliers developing incremental innovations would need to increase their bargaining power over assemblers, and investing in downstream complementary assets has been found to be a promising alternative (Rothaermel, 2001). For example, Rothaermel (2001) found that pharmaceutical incumbent firm’s superior performance after a technological shift can be attributed to alliances with complementary asset firms. In the automotive industry, the consolidation of suppliers into “mega suppliers” (Jacobides et al., 2012) by acquiring complementary business (e.g. Faurecia and Siemens; Johnson Controls and Prince) in order to broaden their value proposition has been found to be a successful strategy (Humphrey & Memedovic, 2003). These observations lead to the following propositions, also shown in figure 3.

Proposition 2a: Lead firms in a rigid industry architecture will appropriate more value from incremental innovations by investing in upstream quasi-integration such as alliances and asset ownership.

Proposition 2b: Suppliers in a rigid industry architecture will appropriate more value from incremental innovations by investing in downstream complementary asset acquisitions and alliances.

LEAD FIRM

	FLEXIBLE I.A (MARKET / MODULAR)	RIGID I.A (RELATIONAL / CAPTIVE)
Vertical Integration Strategy for Incremental Innovation	***Upstream*** No change	***Upstream*** Alliances and asset investments
	Downstream Alliances and asset investments (complementary assets)	***Downstream*** No change

SUPPLIER

	FLEXIBLE I.A (MARKET / MODULAR)	RIGID I.A (RELATIONAL / CAPTIVE)
Vertical Integration Strategy for Incremental Innovation	***Upstream*** No change	***Upstream*** No change
	Downstream Alliances and asset investments (complementary assets)	***Downstream*** Alliances, M&As (complementary assets)

Figure 3: Vertical integration strategy for incremental innovation value appropriation

Radical innovation integration strategies

In the case of radical innovations, which are characterized by competence destroying changes in business models and architectural modifications (Benner & Tushman, 2002; Henderson & Clark, 1990), upstream capabilities are overturned (Wolter & Veloso, 2008) and suppliers have to many times catch up with new technologies as well. In this case a lead firm developing a radical innovation will have increased incentives to vertically integrate upstream operations. This is because explorative product developments create new interdependencies between components and complementary parts, so that transaction costs arising from the complexity of information exchange is high and the codifiability of knowledge is low (Gereffi et al., 2005; Gerwin, 2004; Jacobides & Winter, 2005). Langlois (1992) posits that transaction costs of negotiating, coordinating and teaching suppliers in the face of innovation are the main drivers of vertical integration. From the perspective of lead firms, investing in vertical integration should help value appropriation from explorative innovations since these firms are at the top of the value chain and sell their products directly to the final consumer or through retailers. Thus, vertically integrating turns out to be many times the only option to both lead firms and suppliers, irrespective of the industry architecture, since the upstream market is not developed yet. This firms' integration movement caused by radical innovations is well known by studies on industry evolution and organizational form (Cohen & Levin, 1989; Langlois & Robertson, 1992; Malerba & Orsenigo, 1996).

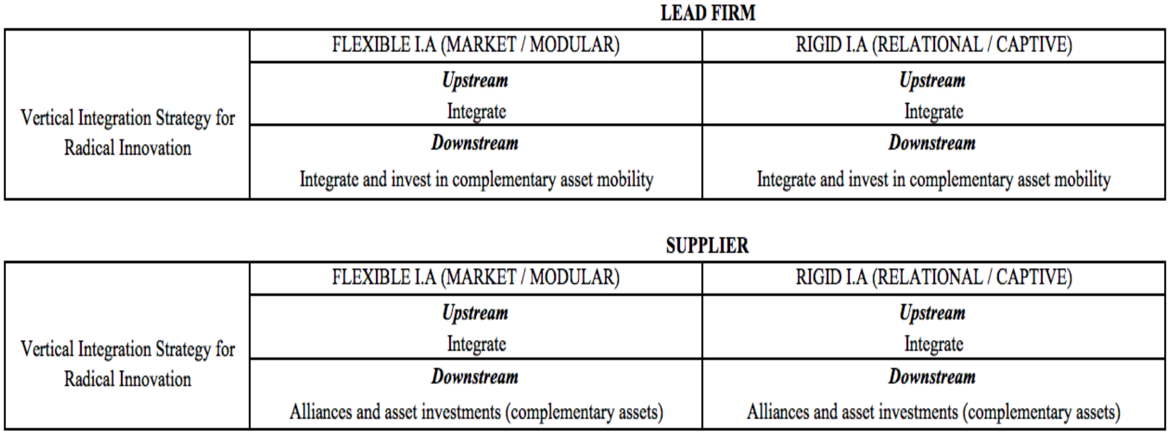
On the other hand, a topic that is less studied in the literature is the case when firms possessing a radical innovation have to integrate their downstream operations (Rothaermel, 2001). From the perspective of lead firms, integrating downstream may be the best available option when a firm possesses a radical innovation. Radical innovations overturn not only product architectures and upstream capabilities but also downstream strategies. Since lead firms are at the bottom of its value chain, their interaction with the final customer is usually a key aspect of their value proposition. For example, Apple owns and operates its own retail chain which provides customers with expert information about its products and also serves as a great source of information regarding customers' experience (Morse, 2011). Following this line of reasoning, Elon Musk has argued that Tesla's approach of owning its own stores and selling directly to customers is crucial since "*dealers have a fundamental conflict of interest between selling gasoline cars and selling the new technology of electric cars…[and] it is impossible for them to explain the advantages of going electric without simultaneously undermining their traditional business*". Therefore, Lead firms in both rigid and flexible industry architectures would need to integrate their downstream operations.

Another important strategy raised by Jacobides et al., (2006) is that firms can reap increased benefits from innovation by investing in complementary assets mobility, i.e. stimulating competition in complementary segments. Moreover, encouraging imitation in the case of radical innovations may be also another viable strategy if the firm lacks at the same time upstream capabilities or co-specialized suppliers (Jacobides & Billinger, 2006; Jacobides et al., 2006). This strategy is also related with "open-innovation" practices (Chesbrough, 2003), which are encouraged when a given innovative development needs to be accelerated through intense knowledge exchanges and external use (Chesbrough & Appleyard, 2007). Thus, I propose that investing downstream complementary asset mobility help firms appropriate value from radical innovation (see figure 4).

> *Proposition 3a: Lead firms will appropriate more value from radical innovations by integrating its downstream operations and investing in downstream complementary assets mobility.*

In the case of suppliers competing in flexible IAs, these firms should avoid acquiring downstream business due to increased tensions and costs associated with those operations since high levels of competition in downstream markets are a characteristic of fast-paced clockspeed environments (Fine, 1998). Although vertical integration should be preferred when a firm wants to increase its market power, high risks of managing fast-paced product lifecycles will lead to quasi-integration strategies (Stuckey & White, 1993). As explained in proposition 1, investing in assets that will appreciate because of innovation (Jacobides et al., 2006) turns out to be the best approach because of high levels of factor complementarity and mobility. The same rationale also works for suppliers placed in more rigid structures. Downstream acquisitions are usually not an option to suppliers in these industries since lead firms are usually much bigger in size and have more bargaining power (Gereffi et al., 2005). Stuckey and white (1993) highlight that although firms in week stages of an industry chain will try to move up to more powerful stages, it is very unlikely that vertical integration costs justify the benefits to be achieved.

> *Proposition 3b: Suppliers will appropriate more value from radical innovations by investing in downstream complementary assets via alliances and asset ownership.*



LEAD FIRM

	FLEXIBLE I.A (MARKET / MODULAR)	RIGID I.A (RELATIONAL / CAPTIVE)
Vertical Integration Strategy for Radical Innovation	***Upstream*** Integrate	***Upstream*** Integrate
	Downstream Integrate and invest in complementary asset mobility	***Downstream*** Integrate and invest in complementary asset mobility

SUPPLIER

	FLEXIBLE I.A (MARKET / MODULAR)	RIGID I.A (RELATIONAL / CAPTIVE)
Vertical Integration Strategy for Radical Innovation	***Upstream*** Integrate	***Upstream*** Integrate
	Downstream Alliances and asset investments (complementary assets)	***Downstream*** Alliances and asset investments (complementary assets)

Figure 4: Vertical integration strategy for radical innovation value appropriation

Conclusions

Studies investigating when, why and how firms should vertically integrate their upstream and downstream operations have largely focus on transaction costs and competence-based theories (Hennart, 1993; Jacobides & Winter, 2005; Madhok, 1996) with little considerations of how innovation and industry architecture shape these decisions (Jacobides & Winter, 2012). The effects of innovation and industry structure have only recently gained momentum in the literature and new research endeavors are necessary to understand under which circumstances firms appropriate more value from innovation. A clear understanding of industry architecture should be the first step towards the study of how firms appropriate value from innovation. I propose that industry architectures are a composition of (1) the rate of change in product developments, known as clockspeed, (2) the degree of modular production and (3) the level of supplier base capabilities. Thus, Jacobides et al., (2006) definition of industry architectures as the rules and roles of production within a sector is now better understood in terms of its determinants and forms, from more rigid to flexible architectures.

This differentiation between rigid and flexible architectures is key to the understanding of how firms will change their boundaries in order to appropriate value from innovation. I propose that in more flexible architectures, firms will encounter greater complementary asset mobility for their product innovations. I highlight that firms' position within the value chain coupled with the specific characteristics of IAs and the type of innovation will shape firms' vertical integration choices both upstream and downstream. In the case of flexible IAs, lead firms and suppliers will appropriate more value from incremental innovation by investing in downstream quasi-integration strategies (alliances and minority stake) for complementary assets. In rigid IAs, even incremental innovations require greater levels of upstream vertical integration for lead firms and suppliers. When a more radical innovation is developed, lead firms would need to integrate their downstream operations and invest in complementary assets mobility (co-opetition and open-innovation), while suppliers would reap more value from radical innovations by investing in downstream complementary assets.

CHAPTER III

Unraveling Value Capture Strategies from Modular Products: The Case of Automotive Industry

Scholars have long noted that more sophisticated and complex products are a source of increased rents to countries with enhanced complex products manufacturing (Hidalgo, Klinger, Barabási, & Hausmann, 2007; Kaldor, 1967; Schumpeter, 1934). At the firm level however, scholarly development is still incipient on how and under which circumstances firms can increase value capture by developing more complex products. In the realm of industrialized products, complexity increases as the number of parts and interactions are raised (Simon, 1962), which requires superior integrative and technological capabilities from manufactures (Acha, Davies, Hobday, & Salter, 2004; Novak & Eppinger, 2001). An important phenomenon capable of changing complex designs and shaping firms' value creation and capture is the modularization of products and production. Modularity has played an important role in the evolution of industries given its capacity to transform vertical structures and manufacturing processes (Baldwin & Clark, 2000; Langlois & Robertson, 1992; Sanchez & Mahoney, 1996). Although modules are designed to have only a few adjacent interface interactions, they concentrate many component interactions within its structure (Baldwin & Clark, 2000; Kamrani & Sa'ed, 2002). Thus, modules are mostly complex systems because they group many individual parts and many specific relationships among them (Simon, 1962; Sosa, Eppinger, & Rowles, 2003; K. T. Ulrich, 2003). Scholars have highlighted that, interestingly, product complexity is an often neglected feature in the literature despite its relevance to product innovation and industrial organization (Ethiraj, Levinthal, & Roy, 2008; Hobday, 1998). It is known that modular product designs and modular production benefit assemblers by increasing manufacturing flexibility and reducing lead time and costs (Baldwin & Clark, 2000; MacDuffie, 2013; Schilling, 2000). However, although modularity is a phenomenon that involves commitment from both assemblers and suppliers in a value chain, scholarly attention has only focused on the product assembler's perspective, leaving uncovered the issue of how module suppliers adjust their operations and capture value from complex modular components. In this context I question: are suppliers capable of increasing industry value capture by investing in more complex systems such as modular components? Which upstream and downstream integration strategies are more conducive of value capture from complex modular systems?

Case studies have shown that automotive first tier suppliers found in modular components an important source of increased rents (Fourcade & Midler, 2005; Whitford & Zirpoli, 2014). However, in order to capture value from the manufacturing of more complex components, suppliers faced many problems in adjusting operations and acquiring new capabilities (Fourcade & Midler, 2005) since complex systems are costly and require high levels of knowledge integration and property rights management (Hobday, 1998; Kline, 1990). To further understanding of how component manufacturers create and capture value from increased investments in complex products, I analyze how component suppliers adjust their vertically related operations in order to increase value capture from complex modular products.

While value creation is seen as the perceived benefit by the consumer or willingness to pay minus opportunity costs, value capture is intrinsically related to value creation since it represents the firm’s ability to appropriate rent and is a necessary condition to firms’ long term viability (Bowman & Ambrosini, 2000; Brandenburger & Stuart, 1996). Baldwin (2014) argues that firms need to understand both technical and industry architectures in order to sustain competitive advantage. On the one hand, technical architectural knowledge lies on the understanding of the functions and components of a technical system (Henderson & Clark, 1990), while industry architecture knowledge is defined as the capacity to understand the dynamics of “rules and roles” played out in an industry (Brusoni, Jacobides, & Prencipe, 2009; Jacobides, Knudsen, & Augier, 2006). Baldwin (2014) also posits that industry architectures are shaped by the technical architecture of products (i.e. product-specific characteristics that determine the manufacturing process) and the contract structure of organizations (i.e. intra and inter-organizational arrangements of production and division of labor). In this context, firms can create a “dynamic architectural capability” by successfully controlling “superior solutions” to a complex system, coupled with boundary management and intellectual property protection (Baldwin, 2014). For example, Henkel and Hoffman (2014), using a simulation model, propose that firms can increase value capture by investing in products’ modular architecture, since the ownership of a modular product design confer firms with increased bargaining power in the industry due to the proprietary control over a complex system. Therefore, firms providing a modular solution to a problem are better able to hold a strategic position in the value chain and create more value to its customers (Baldwin & Clark, 2000; Fourcade & Midler, 2005; O'Grady, 1999).

It is important to note that in the realm of complex product manufacturing there are two main players with distinct roles, product assemblers (which can take the role of system integrators) and suppliers. Thus, value capture strategies are shaped not only by firms' internal capabilities but also by the firm's location in the value chain and its vertical integration configuration (Argyres & Bigelow, 2010; Kapoor & Adner, 2012; Teece, 1996). In this case, scholars have noted that suppliers manufacturing more complex and technologically advanced products need to strategically manage their upstream and downstream integration in order create more value from innovation (Adner & Kapoor, 2010; Novak & Eppinger, 2001). Considering that product modularity, innovation and vertical integration management are intrinsically related and are key elements for firms to hold competitive advantage (Baldwin, 2014), I study how firms combine these capabilities and increase their value capture within an industry sector. Specifically, I study how automotive industry suppliers took advantage of increased modular production spurred by automakers (also known as OEM – Original Equipment Manufacturers) and increased their value capture through the investment on modular products. Modular products are considered as a superior solution to a technical problem and firms are motivated to develop new modules in order to capture more value than just selling single components (Ethiraj & Levinthal, 2004). In this context, since it is known that firms developing new products and technologies, specially in the context of modular production, need also to integrate external sources of knowledge and resources (Argyres & Bigelow, 2010; T. E. Stuart, 2000), I also investigate the moderating role of manufacturing integration both upstream and downstream.

Considering the important changes occurring in the automotive industry, which has struggled with the tensions between vertically integrating and opening its supply chain to modular products (Clark & Fujimoto, 1991), and the fact that automakers rely extensively on their suppliers' capacity, this study sheds light on how automotive component suppliers manage their modular products and innovation coupled with vertical integration decisions in order to increase value capture. Although many studies have evidenced that module suppliers have increased their bargaining power as OEMs spun off manufacturing activities and invested in modular production (Fourcade & Midler, 2005; Jacobides, MacDuffie, & Tae, 2012; Whitford & Zirpoli, 2014), it is still unknown the effects of an increased modular component focus on suppliers' value capture. Yet, the literature is still incipient in the understanding of how component suppliers increase value capture within an industry sector through the development of modular innovations and supply chain integration, considered as important dynamic capabilities (Eisenhardt & Martin, 2000; Teece, Pisano, & Shuen, 1997).

The results show that suppliers do not appropriate more value than their competitors if they focus only on more modular products, indicating that these firms need to invest in complementary capabilities to sustain a competitive advantage and profit from the manufacturing of complex products. On the other hand, innovation developments in modules was found to be an important mechanism of value capture. Additionally, suppliers also reap more value from their modular products when they invest in joint operations with downstream buyers and also by integrating and expanding their manufacturing capabilities upstream through mergers and acquisitions. However, possessing increased numbers of manufacturing strategic alliances was found to be negatively associated with suppliers' capacity to reap more value from modular products. These results contribute to value capture from innovation and dynamic capabilities literature by highlighting that firms competing in segments of tight margins and great resource dependency can increase their value capture by investing in new product technologies and integrating their manufacturing operations (Mahoney, 1992; Rothaermel, Hitt, & Jobe, 2006). These findings are also particularly important to the literature on strategic modularization and complexity management (Ethiraj & Levinthal, 2004; MacDuffie, 2013) since it provides a perspective from the suppliers' side on how these firms can benefit from more modular production systems. Finally, this study also contributes to the literature on firms' vertical integration decision by revealing that when products are more complex and involve important intellectual property management, engaging in many alliances can be a burden since it increases the risks of unwanted knowledge spillovers and increased costs of coordinating multiple strategic operations (Lahiri & Narayanan, 2013; Rothaermel, 2001).

THEORY DEVELOPMENT

Product Modularization and Complexity

Modularity in the strategic management literature has drawn attention to the role of modular production on firms' cost reductions, innovation developments, organizational flexibility and industry structure (Henderson & Clark, 1990; K. Ulrich, 1995; Wolter & Veloso, 2008). Modules are developed with the purpose of simplifying the complexity of a given product and its production system. Thus, a modular product should be designed as a set of sub-assemblies that can be combined in the formation of a new product (Baldwin & Clark, 2000; Romme, 2003; K. Ulrich, 1995). The adoption of a modular production system has been related to important changes in industries’ dynamics of bargaining power and also on its division of labor (Langlois & Robertson, 1992; MacDuffie, 2013; Malerba & Orsenigo, 1996). It is known also that firms work continuously to improve particular technological subsystems such as modules as industries evolve and mature. Product modularity is considered as an important element of industries’ evolution, since it allows firms to focus on their core competences and reduces complexities of design (Ethiraj et al., 2008). Thus, the basic idea of modularity is to decompose a complex product or system into separate parts that can be managed independently and hierarchically assembled. Modular product architectures are designed to reduce interdependencies among sub-systems, as modules are defined as a network of components that share interfaces in order to function as a whole (K. Ulrich, 1995). Since modules are designed and produced independently, modular production systems allow also firms to further specialization (Langlois and Garzarelli 2008), which in turn can influence the division of labor within an industry (Langlois and Robertson 1992; Baldwin and Clark 1997; Sturgeon 2002; Langlois 2003).

However, integration and manufacturing challenges of modular products vary significantly between assemblers and suppliers. While assemblers achieve gains of efficiency, increase flexibility and reduce costs from product modularization, suppliers manufacturing modular components will face increased technological and integration challenges due to higher system complexity. Based on Simon (1962), (Novak & Eppinger, 2001)) posits that product complexity is the result of (1) the number of components to specify and produce, (2) the total number of interactions among those components, and (3) the innovativeness of the product, while Hobday (1998) highlights that complex products are also more costly and engineering-intensive. It is generally accepted that modules are designed with the purpose of encapsulating as many interdependencies among parts as possible. Managers and engineers consider carefully the design structure matrix (DSM) in order to map the design-interface structure of a complex system and develop modular solutions clustering single components and reducing adjacent interfaces and interdependencies (Baldwin & Clark, 2000; Eppinger, Whitney, Smith, & Gebala, 1994; Sosa et al., 2003). Therefore, modules can be seen as complex components since they possess many individual parts sharing multiple within-system interfaces (Sosa et al., 2003; K. T. Ulrich, 2003).

Particularly in the automotive industry, modular components are characterized by a great number of parts and interactions, which are also embedded in a context of increased innovative pressures (MacDuffie, 2013). Scholars have noted that automotive suppliers had to overcome many challenges in order to upgrade their manufacturing capabilities to cope with more complex modular component (Fourcade & Midler, 2005; Kotabe, Parente, & Murray, 2007). Fourcade and Midler (2005) provide evidence from an in depth case study that first tier automotive suppliers had to develop new manufacturing and coordination capabilities to produce modules, which are not only more complex in terms of number of parts and interactions but also more difficult to coordinate within the final product assembly line. Studies on complex products and systems highlight that manufacturers of more complex subsystems are able to differentiate themselves from competitors and increase the value of its products (Baldwin, 2014; Hobday, 1998; Langlois & Robertson, 1992; Rivkin, 2000), however extant literature is very incipient on the understanding if module suppliers are able to capture more value from such complex components.

From a theoretical standpoint, the issue of how firms capture value from complex products' manufacturing should be seen under both transaction costs economics (TCE) and resource/capabilities perspectives. TCE scholars have pointed out that coordination costs rise when firms increase the complexity of its products (Klein, Crawford, & Alchian, 1978; O. E. Williamson, 1983). That is because when the number of parts and interactions necessary to manufacture a product increase, asset specific investments and monitoring costs also increase as firms need to invest more in supervision, inspection, maintenance and quality control for example (Banker, Datar, Kekre, & Mukhopadhyay, 1990; Datar, Kekre, Srinivasan, & Mukhopadhyay, 1990; MacDuffie, Sethuraman, & Fisher, 1996). In this case vertical integration emerges as a solution to reduce transaction costs, since internalized asset specific investments would reduce coordination costs and other contacting-related issues such as opportunism and knowledge expropriation (Klein et al., 1978; Langlois & Robertson, 1992; Novak & Eppinger, 2001; O. E. Williamson, 1983). On the other hand, the resource- capabilities-based literature also emphasizes that firms should internalize and keep proprietary activities in which they have a superior skill (capability) compared to other players in the market (Argyres, 1996; Argyres & Zenger, 2012; Jacobides & Winter, 2012). Since the capacity to develop and assemble a complex product is usually used as a competitive advantage due to product differentiation and difficult substitutability (Baldwin, 2014; Hobday, 1998; Novak & Eppinger, 2001), firms having such capability have strong incentives to have it internalized.

Integration decisions vary also across the value chain. Adner and Kapoor (2010) highlight that past research has neglected the location of activities along the value chain and demonstrate that upstream and downstream challenges have different impact on value creation from innovation. Therefore, it is important to look at both upstream and downstream vertical integration decisions in order to further understanding how suppliers adjust their operations to capture more value from complex components. I explain in the following sections how suppliers can increase value capture by focusing on the manufacturing and innovation of modular components which require increased investments in vertical integration both upstream and downstream.

Value Capture from Modular Solutions

The basic notion of modularity is that a product should be designed such that functions have a one-to-one mapping and components are ready for coupling-decoupling (K. Ulrich, 1995). Thus, full modularity means that a product should be totally decomposed into separable components where each component can be developed independently (Langlois, 2002). Consider that some products can be more easily redesigned into modular products than others. While the computer industry has successfully implemented a modular production system worldwide, the automotive industry has demonstrated that modular production is not always feasible given product complexities and institutional barriers (Jacobides et al., 2012; Jacobides, MacDuffie, & Tae, 2015; MacDuffie, 2013). Thus, fully modular systems are rare in practice, and particularly in the automotive industry, vehicles have not evolved to be a fully modular product. By exploring when value capture migrates within a value chain, Jacobides et al, (2012) concluded that in the case of the automotive industry, OEMs have been able to keep increased levels of value captured over time due to their role as systems integrators and “guarantors or quality” as OEMs have control of the final product design and have integration capabilities difficult to imitate. In this context, the authors highlight that OEMs are very cautious about modular outsourcing since relying on suppliers for the design and manufacturing of modules increased suppliers' bargaining power. In fact, module suppliers are firms considered to have superior manufacturing and organizational capabilities due to their capacity to develop and deliver complex components (Fourcade & Midler, 2005). From a design perspective, products with more complex designs are more difficult to be copied since the product's structural complexity hampers reverse engineering (Lippman & Rumelt, 1982; Pil & Cohen, 2006). A greater number of intricate relationships between each function and components in a complex product requires an increased number of experiments in order to unravel its technology (Rivkin, 2000). Thus, by manufacturing high quality modules, suppliers would be able to increase their bargaining power over downstream buyers (Whitford & Zirpoli, 2014).

In the case of the automotive industry, the concept of a module is viewed as a "large chunk of physically adjacent components produced as a subassembly by a supplier" (MacDuffie, 2013). The modular production system was established by OEMs mainly in the 90's and early 2000's, which assigned specific suppliers to manufacture modules accordingly to their specifications. OEMs increased the delegation of production and innovation development to system suppliers expecting to reduce manufacturing costs, increase production flexibility and focus on their core competence as system integrators (MacDuffie, 2013; Whitford & Zirpoli, 2014). OEMs sourcing in modules can reduce lead time and manufacturing costs, while also removing complexities in the assembly line and allowing for better quality testing and technologic advancements of modules (Jacobides et al., 2012). Therefore, tier one suppliers have identified an important source of value capture through the creation of modular solutions to complex subsystems, which incurs in changing products' design and increasing assembling efficiency (Fourcade & Midler, 2005).

Whitford and Zirpoli (2014) reveal from interviews with automotive supplier executives that the decision of OEMs to delegate the manufacturing of modules was happily received by suppliers. This was seen as an opportunity to learn about new manufacturing processes and acquire new capabilities. First tier suppliers would be responsible for investments in R&D and innovation in those products sold to OEMs, which increased suppliers' capacity to add value to their products. Moreover, the high costs involved in substituting suppliers due to the great levels of tacit knowledge sharing and fixed costs of production reduces module suppliers' substitutability (Whitford & Zirpoli, 2014). Suppliers then started to purposely seek new ways to solve their clients' problems through modular solutions and have largely increased they investments in module developments (Fourcade & Midler, 2005). Such phenomenon has been highlighted by specialized industry reports, which provide evidence that first tier suppliers have increased their value capture in the industry by investing in technological differentiation and product segments with increased margins such as powertrain and panel modules (Roland Berger, 2014). This opportunity to get increased margins from modular products indicates that suppliers focusing more on modules manufacturing would also capture more value in their industry segment. Thus, I hypothesize that:

Hypothesis 1: Suppliers with increased focus on modular products will have a higher industry value capture.

Coupled with the investment and focus on manufacturing more complex products such as modules, suppliers need also to protect their modular developments against imitation in order to sustain an increased value capture in the industry. The notion that keeping proprietary valuable assets and knowledge provides firms with a competitive advantage is well established (Barney, 1996; Kogut & Zander, 1992; Teece, 1996; Wernerfelt, 1984), however this understanding from a modular component perspective is scant in the literature. Firms can reduce the risks of product substitution and imitation by developing not only valuable complex systems but also by engaging in more innovative solutions. Thus, a modular component that also has unique innovative features providing a superior solution to a complex system will be a product of increased perceived and aggregated value.

Particularly in the automotive industry, modules are tailored specifically to each car, which demands high levels of knowledge exchange and open communication between suppliers and OEMs (Dyer & Nobeoka, 2000; Kotabe et al., 2007). Since different modules must be easily integrated in the assembling of the final product, modular production systems have to rely on an open product platform. Moreover, car modules are developed under the specifications and design of OEMs, and modules developed for the same function usually differ across an OEM’s product line, since different cars have different specifications and there are no universal standards in the industry (MacDuffie, 2013). Thus, buyer-supplier relationships in the automotive industry are teemed with risks of opportunism from both sides as the OEM needs to deeply understand the technology and functionality of its outsourced products because it bears the legal liability of the final product and is responsible for final product defects and failures (Jacobides et al., 2015).

On the other hand, this also increases the risks of suppliers' intellectual property (IP) expropriation since their products are always under the OEMs' scrutiny (Whitford & Zirpoli, 2014).

The development of innovative products has been referred in the literature as one of most important dynamic capabilities a firm can posses and is largely regarded as a source of increased rents (Eisenhardt & Martin, 2000; Rothaermel & Hess, 2007; Teece, 2007; Winter, 2003). Thus, I propose that suppliers developing innovative modules would be better able to increase value capture in their industry sector. Along with investing in more modular products, it is important to suppliers also innovate and protect their IP in order to avoid imitation and reduce substitutability. Innovating in modular products would allow suppliers to increase their value capture by enhancing the efficiency and quality of their products, which leads to increased value capture.

Hypothesis 2: Suppliers with increased focus of modular product innovations will have a higher industry value capture.

Value Capture and Upstream Integration

Following the rationale that component suppliers with increased focus on modular products and technologies would be capable of having a superior value capture in their industry sector, I now consider vertical integration as a key element that suppliers should manage in order to increase value capture from their modular products. The investigation on how firms adjust their vertical structure to increase value capture from their products has been an important topic in the strategic management literature (W. Cohen & Levin, 1989; Gereffi, Sturgeon, & Humphrey, 2005; Jacobides & Winter, 2012; Mahoney, 1992; Porter, 1981). It is known that the decision of vertically integrating activities is based mainly on the transaction costs involved in supply agreements (Coase, 1937; Jacobides & Billinger, 2006; Langlois, 1992; O. E. Williamson, 1975) and that firms decide to internalize key activities that are vulnerable to market opportunism in order to avoid contractual hazards (O. Williamson, 1985). Williamson (1983) highlights that the main sources of transaction costs are the frequency of contract updates, uncertainty, opportunism and asset specificity while increases in one or more of these factors will create pressures for vertical integration. Coupled with transaction costs, scholars have proposed also that firm capabilities and innovation are also key factors determining vertical organizational structures (Jacobides & Billinger, 2006; Utterback & Suarez, 1993; Wolter & Veloso, 2008). Firm capabilities, from the perspective of the resource-based and knowledge based view (Barney, 1996; Kogut & Zander, 1992; Peteraf, 1993; Wernerfelt, 1984), will shape firms' boundaries as make or buy decisions are also made based on internal routines, knowledge pool and skills (Argyres & Bigelow, 2010; Wolter & Veloso, 2008).

Together with the firm capabilities heterogeneity and transaction costs, other aspects such as the introduction of a radical innovation, product modularization or the occurrence of exogenous technological shocks are also capable of overturning product architectures and destroying firm competences which in turn shape vertical organizational design (Jacobides & Winter, 2012; Teece, 1996; Wolter & Veloso, 2008). Firms' integration decisions are intrinsically related to their selection of innovation activities, since firms may need to change their boundaries in order to appropriate value from innovation (Adner & Kapoor, 2010; Rothaermel et al., 2006). Thus, increasing the complexity of products such as modules also requires new technological and integrative capabilities (Fine, 1998; Furlan, Cabigiosu, & Camuffo, 2014; Langlois & Robertson, 1992). Firms facing the challenges of manufacturing more complex products have to be able to manage difficult to transfer tacit knowledge and avoid activities that increase the risks of knowledge expropriation. In this case, vertical integration emerges as an important organizational choice to mitigate the risks of contractual hazards, which occur when firms establish asset-specific investments under conditions of uncertainty (O. Williamson, 1985). From a capabilities perspective, vertical integration also enhances firm technological specialization, improves operational efficiency and leverage scale economies (Harrigan, 1984a; Mahoney, 1992; Teece, 1996). Specifically with regards upstream integration, the extant literature has recently drawn attention to the role of a firm's supply chain integrative capability as a key driver of performance heterogeneity (Clausen, Pohjola, Sapprasert, Verspagen, & Verspagen, 2012; Handfield, Petersen, Petersen, Handfield, & Ragatz, 2005; Hult, Ketchen, & Arrfelt, 2007; Song & Thieme, 2009).

Adner and Kapoor (2010) point out that contracting with suppliers for more complex and innovative components increases the risks of technological uncertainty (when the supplier is not capable of finding appropriate solutions to product development) and behavioral uncertainty (when the supplier opportunistically renegotiates agreements). Thus, vertical integration turns to be an important mechanism of value capture to firms manufacturing complex products since supply uncertainties and opportunistic behavior from more technologically capable suppliers diminish rent appropriation. Vertical integration is particularly important to the development and retention of new ideas about emerging technologies (Hoetker, 2004), and also when interdependencies and complexities demand heuristic and cognitive search (Nickerson & Zenger, 2004). In the case of complex products, vertical integration is preferred instead of incurring in the coordination costs arising from a myriad of independent suppliers (Afuah, 2001).

Specifically with regards to upstream activities, the acquisition of manufacturing operations is an important strategy pursued by firms willing to integrate new knowledge, reduce costs and reap gains of efficiency and productivity via scale and scope economies (Chatterjee, 1991; Hitt, Hoskisson, Johnson, & Moesel, 1996). Thus, expanding upstream capabilities through mergers and acquisitions can be important to module suppliers willing to increase value capture in their industry segment. Despite the costs and risks involved in M&As such as overvaluation, unrelated diversification issues and organizational, cultural and managerial adaptation challenges (Harrigan, 1984b; Hitt et al., 1996; Villalonga & Mcgahan, 2005), focusing on manufacturing purposed M&As is a less risky investment when a firms is embedded in a more mature industry with longer product life cycles (Fresard, Hoberg, & Phillips, 2013a). M&As are also recommended when firms want to increase market power, own and control scarce resources, overcome barriers to entry and access new technologies (Ahuja & Katila, 2001; Hitt et al., 1996; Kapoor & Lim, 2007).

Particularly for suppliers, these firms can access important complementary assets necessary to the manufacturing of more complex products (e.g. modules) which usually require a combination of different knowledge capabilities (Ethiraj & Levinthal, 2004). Yet, suppliers can raise entry barriers by acquiring and controlling upstream activities as new entrants would have to either operate in both stages involved or source in products at a higher price from vertically integrated players (Bain, 1956; Porter, 1980). Suppliers may achieve industry strategic advantages via upstream vertical ownership integration by reducing the number of suppliers and foreclosing competitors (Mahoney, 1992). Upstream M&As are also capable of reducing the costs and improving efficiency of R&D activities since firms will be able to reduce duplicated efforts in research activities (Ahuja & Katila, 2001; Hoberg & Phillips, 2010). For these reasons, suppliers can benefit greatly from the acquisition of new manufacturing plants to become better able to sustain an advantageous position in the industry and hold the necessary resources to manufacture better products. Given the complexity of modular products and the increased technological and managerial requirements to successfully deploy modules in the automotive industry, I also propose that suppliers capable of increasing their manufacturing capabilities through M&As will be better positioned to capture more value in its industry segment.

Hypothesis 3: Suppliers with increased levels of investments in manufacturing M&As will have a higher industry value capture from their modular products.

More recently, scholars have explored how firms manage their boundaries through quasi-integration initiatives such as alliances in order appropriate more value from new products (Lahiri, 2010; Phelps, 2010; T. E. Stuart, 2000). To meet the multitude of requirements involved in developing new products, firms have to invest not only in internal research and development activities but also in external sources of knowledge so they can benefit from a portfolio of different activities (Hoffmann, 2007). Past research has vastly addressed the importance of interorganizational relationships as crucial factor for sustaining competitive advantages in different industries (Lavie & Rosenkopf, 2006;

Parkhe, Wasserman, & Ralston, 2006). Strategic alliances are important to the development of explorative innovations through the creation of new organizational structures while firms can also exploit new products and practices from their traditional processes with new partners (Christensen & Overdorf, 2000). Therefore, working together with other organizations implies the acquisition and creation of new knowledge and the development of new resources to the firms involved (Ahuja, 2000).

In contrast to vertical integration through full ownership, alliances are more flexible investments that provide firms with access to complementary assets and knowledge necessary to create new products, access new markets and improve manufacturing efficiency (Lahiri & Narayanan, 2013; Lavie, 2007; Rothaermel et al., 2006). Thus, alliances are cooperative semi-integrated organizational forms that can be used as an alternative to vertical ownership. It is important to note that past research has pointed out that managing strategic alliances is a difficult task and usually involves high levels of resource commitment and other inherent risks. Coupled with the high levels of failure among alliances formed (Polidoro, Ahuja, & Mitchell, 2011) are the problems of knowledge spillover (Teece, 2000), cultural differences (Sirmon & Lane, 2004), and managerial problems such as a lack of trust and competition between partners (Polidoro et al., 2011). Therefore, when alliances are established and managed with a clear and specific purpose and are strategically in line with the firms' core objectives, the performance and innovative outcomes are found to be positive (Lavie, 2007; Lavie, Kang, & Rosenkopf, 2011; Phelps, 2010).

Alliances are specifically important to firms’ access to complementary assets and capabilities utilized to the development and improvement of new products (Rothaermel, Hitt, and Jobe, 2006). Scholars have also noted that alliances are an important source of competitive advantage since the formation of a portfolio of joint activities confers the firm with a unique pool of resources (Eisenhardt & Schoonhoven, 1996), which in turn can also be a mechanism by which suppliers leverage their knowledge in order to manufacture better products, including modules. With a portfolio of alliances, suppliers can learn how to adapt to changes in inputs and processes (Sampson, 2007), which can lead also to production improvements and gains of efficiency. Thus, it is expected that module suppliers with a large manufacturing alliance portfolio would be better able to improve their capacity to manufacture more complex products and respond quickly to market changes (Dess, Rasheed, McLaughlin, & Priem, 1995; Duysters, de Man, & Wildeman, 1999). Additionally, strategic alliances are also known to reduce firms’ costs through the access to new and improved techniques that help achieving scale and scope economies (Bettis, Bradley, & Hamel, 1992; Gilley & Rasheed, 2000). Following this line of reasoning, I propose that suppliers can increase their value capture form modular products by increasing their manufacturing-purposed alliance portfolio.

Hypothesis 4: Suppliers with an increased manufacturing-based alliances portfolio will have a higher industry value capture from their modular products.

Value Capture and Downstream Integration

In more rigid industry structures, such as the automotive, firms encounter greater levels of resource dependencies and power asymmetries. That is because there is a high degree of product complexity, difficulties in codifying knowledge and the presence of lead firms that keep the role of system integrators and exert great bargaining power over its suppliers base (Gereffi et al., 2005; Jacobides et al., 2015). These industries are also characterized by increased levels of vertical integration, and innovation developments usually occur within a close buyer-supplier relationship. In this context, product integration and tacit knowledge difficulties create pressures for vertical integration. The literature has shown that even small product changes can create systemic problems due to the many interactions between parts (Kotabe et al., 2007) and that closer buyer-supplier relationships are important determinants of efficiency gains (Dyer & Hatch, 2006; Dyer & Nobeoka, 2000). Past research has also vastly acknowledge the benefits of joint operations between suppliers and OEMs to the automotive production system (Albornoz and Yoguel, 2004; Clark and Fujimoto, 1991; Kotabe et al., 2007; Takeishi, 2001). However there’s still a dearth of research on how suppliers manage their downstream relationships with OEMs in order to increase their value capture from modular products (Whitford & Zirpoli, 2014).

The capacity to integrate different operations through equity alliances is an important mechanism where firms can absorb critical knowledge from external sources and combine it with the knowledge that resides within the firm (Kogut, 2013). Case studies have shown that Toyota works intentionally and strategically with their suppliers in order to increase trust, knowledge sharing and efficiency of operations while some other OEMs would develop their alliances mainly to reap cost benefits without really engaging into relation-specific activities (Dyer & Hatch, 2006; Dyer & Nobeoka, 2000). More recently, researchers have pointed out that the OEMs in general have increasingly invested in co-design with their suppliers and in supply chain integration (Jacobides et al., 2012; Kotabe et al., 2007) but little attention has been drawn to the suppliers perspective. While OEMs still have almost full control in terms what product they want and how much they are willing to pay for it, they also want their suppliers to catch up with new technological advances (Ciravegna & Maielli, 2011; Whitford & Zirpoli, 2014). In this case a more focused approach on the development of joint operations with OEMs can provide suppliers with cost advantages, knowledge spillovers such as increased know-how, as well as increased trust and reputation (M.-P. Kang, Mahoney, & Tan, 2009; Kotabe et al., 2007) thus increasing substitution costs to the OEM. Joint operations with OEMs increase the development of joint innovations (Womack, Jones, & Ross, 1990) that can be used by suppliers as a mechanism to increase the value of its products.

Downstream buyers having difficulties in understanding and operating complex products will also attribute less value to it (Adner & Kapoor, 2010). Thus, considering that the automotive industry is characterized by increasing market pressures for new products as well as higher safety and environmental standards that increase the complexity of its processes (MacDuffie & Fujimoto, 2010), the suppliers' ability to coordinate activities with its downstream buyers through supply chain integration is of paramount importance (Hult et al., 2007; Lazzarini, Claro, & Mesquita, 2008). Given the aforementioned benefits brought by an increased integration of operations between suppliers and OEMs in the automotive industry, I propose that increased levels of downstream manufacturing integration through alliances with OEMs will help suppliers increase their value capture from modular products.

> *Hypothesis 5: Suppliers engaging in more downstream alliances will have a higher industry value capture from their modular products.*

METHOD

Sample

The automotive industry was chosen as the context to explore how suppliers capture value from modular products given the particular characteristics of resource-dependency, supply chain configuration and technological evolution of this industry. Considering also that automakers rely extensively on their suppliers' capacity and that the automotive industry has a particularly rigid and OEM-led supply chain configuration (Jacobides et al., 2012), studying how suppliers create new and complex products and capture value from it can be particularly insightful from this setting. While a great deal of the empirical research on firms' innovation and value capture strategies is based on industries with a less rigid and less "OEM-controlled" supply chain (e.g. chemicals, pharmaceutical and semiconductors industries), there's still a dearth of research on how firms competing in rigid industry structures such as the automotive industry manage their boundaries and resources in order to capture more value in an ever increasing dynamic and innovation-led environment. In contrast to other industries, the automotive industry is characterized by a highly regulated and complex system of operations, which constrains more open product architectures, as well as a high dependency on the OEMs as “system integrators” (Jacobides et al., 2015). This particular setting turns the automotive industry into a field ruled by “dinosaurs” (MacDuffie & Fujimoto, 2010), since the entry of new players is curbed by the complexities involved in managing safety rules, greener and fuel-efficient demands and constant technological updates. Thus, suppliers of the automotive industry have their product development activities embedded in a system of close supervision and direct participation by OEMs, which have the largest portion of value capture in the industry (Jacobides et al., 2015).

I focused on the top 500 tier one suppliers (suppliers selling to OEMs directly) listed on the automotive news magazine and automotive specialized website Marklines. The selection criteria was based not only on annual sales, but also on if the firm’s primary business is the automotive industry, if the firm has multiple contracts with OEMs and if the firm serves the global market. By limiting the sample to one industry I can also control for cross-industry variations as well as it ensures that alliance-formation actives and its outcomes are comparable across firms (Stuart, 2000).

Drawing from the list of top 500 global tier one suppliers as of 2013, I was able to get financial information of 318 publicly traded firms. From that, I decided to focus on firms operating in the U.S since it is the second world’s largest market, having the presence of all major automakers and suppliers, while also being the market where technological innovation and competition is more intense. After selecting only firms with U.S manufacturing physical presence, the final sample ended up including 240 firms. The data was sampled from the period of 2004 to 2011, thus capturing the automotive industry after changes that occurred in the 90's and early 2000' in terms of modular production processes and international competition (MacDuffie & Helper, 1997), and the ongoing technological race since early 2000' (Holweg & Pil, 2008).

Data Collection

Firms' financial information was gathered from COMPUSTAT and Bloomberg databases. Deals information regarding M&As and alliances was obtained initially from Thomson's SDC Platinum, and later on cross checked and expanded via ORBIS, Lexis-Nexis and also through companies' websites, annual reports, and filings such as 10K and 20F. Each merge, acquisition or alliance encountered was properly coded in terms of date, identities, agreement type, location and Standard Industrial Classification (SIC). Alliance termination was also tracked in the aforementioned databases (in cases of joint venture takeover, liquidation or acquisition) and also through internet search and ultimately, contacting the firms. U.S patents data was obtained from the United States Patent and Trademark Office (USPTO). U.S patents are an important source of firms' innovative activity since protecting technology in the United States has been considered an strategic decision for global firms (Phelps, 2010), specially for automotive players which have great incentives to protect their technology in the second largest and world's most competitive automotive market. Moreover, USPTO is known for its effective intellectual property protection and the rigor and fairness involved in the process of grating a patent (Pavitt, 1988). Lastly, sales agreements from automotive first tier suppliers was obtained from the Marklines database. Information regarding each specific part or component sold to OEMs for a given model in a given year was obtained coupled with the locations of both supplier and OEM. First tier suppliers have on average around 90% of their sales from OEMs (Roland Berger, 2014) which indicates that data on sales agreements with OEMs represents well first tier suppliers' sales of manufactured products.

Dependent variable

Firm relative profitability was selected as the measure of value capture[3] (Bae & Gargiulo, 2004; Lavie, Kang, & Rosenkopf, 2011). Relative profitability is preferred instead of individual profitability given the hypotheses on sustaining competitive advantage over competitors. Considering that net profit is a measure that incorporates many financing and accounting decisions sometimes nonrelated with the firms' main activity, the earnings before interest, taxes, depreciation and amortization (Ebitda) is a more useful and comparable measure of firm profitability for firms from different countries and with different taxation and accounting regimes. The measure is calculated by subtracting firms' *i* Ebitda from the industry's average Ebitda *j* in year *t*.

$$PROF_{i,t} - \left[\sum_{j=1}^{K_{i,t}} (PROF_{j,t} / K_{i,t}) \right]$$

Independent variables

Modules in the automotive industry are components that encompass many different parts and interactions among them (Kotabe et al., 2007; MacDuffie, 2013). Modules are sold to OEMs through detailed contracts specifying quantities and tenure for a specific car

---

[3] Value capture is referred in the literature as the result of price of goods sold minus costs and a positive value capture means also that value has been created (Bowman & Ambrosini, 2000; Brandenburger & Stuart, 1996).

model being manufactured in a specific plant. I considered *modular production intensity* as the count of all supply agreements of modular products manufactured by supplier *i* in year *t* divided by the total number of supply contracts in year *t.* This ratio is important to capture suppliers' propensity to develop modular products independent of its products portfolio size. *Modular innovation intensity* was measured as the count of all patents applications of modular products and technologies made by supplier *i* in year *t* divided by total number of patent applications in year *t.* Modular component or system patents were tracked by carefully looking at each firm's patent applications abstract and claims describing a modular product or design. Capturing the firm's share of modular innovations instead of the full count is important to avoid distortions caused by firm size. Suppliers' engagement in strategic alliances[4] with downstream buyers was named *downstream alliances* and measured as the average number of alliances established and sustained with OEMs in a given year. Upstream manufacturing purposed integration (*upstream M&A integration*) was measured as the count of all manufacturing purposed mergers and acquisitions made by a given supplier in a given year. Using the same method, I also measured *upstream alliance integration* intensity as the count of the total number of manufacturing-purposed alliances made by a given supplier in a given year (Rothaermel & Boeker, 2008; Stuart, 2000; Van de Vrande, 2013).

---

[4] Alliances were considered only in the case of manufacturing equity/non-equity joint ventures, joint operations agreements and product development/technology exchanges (Stuart, 2000). From the total number of 1231 alliances formed in this sample, 94% were equity joint ventures.

Control variables

In order to control for other aspects influencing automotive firms' performance and innovation I included the following control variables. *Firm age* as the number of years since establishment. *Firm size*, measured as the total number of employees. *Leverage ratio*, measured as the ratio of total debt over total equity. *R&D Intensity* measured as the total R&D expenditures over total sales. *Exports intensity* was measured as ratio of foreign sales over total firm's sales. *Past performance* was measured as the firm's Ebitda in year t-1. *Non-manufacturing alliances* as the count of all non-manufacturing purposed strategic alliances, as well as *non-manufacturing M&As*. *Innovation output* measure as total count of patent applications per year. Lastly, I also measured each firm's network status based on the structure in which it was embedded. *Network centrality* was captured using Bonacich's (1987) eigenvector centrality scores. *Structural holes* captures resource accessibility and brokerage position (Burt, 1992) and was measured using the structural holes procedure in UCINET (Borgatti, Everett, & Freeman, 2002).

Analytical procedure

Since the data has a longitudinal configuration, I tested my models using panel GLS regression. I employed the Hausman test in order to evaluate the necessity of a fixed-effects or random-effects approach. The Hausman test indicated that a fixed-effects model should be used. Variance inflation factor was significantly low (below 3) in all models, thus ruling out the risk of multicollinearity. All independent variables were lagged one year to avoid reverse causality and simultaneity. Yet, all variables involved in interaction terms were mean centered. Descriptive statistics are reported in Table 1.

RESULTS

Table 2 shows the fixed effects panel regression results. Model 1 provides results for the baseline hypotheses 1 and 2 and control variables. Firm age effect was found to be significant and negatively related to relative profitability (b = -12.82 p< 0.05) indicating that younger firms are better able to capture more value in this industry sector. Firm size coefficient is significant and positively related to increased value capture (b = 0.009 p< 0.001) showing that larger suppliers are more capable of sustaining increased profitability over time. Non-manufacturing M&As are negatively related to increased value capture (b = -132,32 p< 0.001). Past performance is positively related with relative profitability (b = 0.55 p< 0.001) and firms with increased structural holes network position were found to have increased relative profitability (b=310.7 p< 0.001) given their capacity to connect to a wider and richer pool of resources and knowledge (Ahuja, 2000; Burt, 1992). Moreover, model 2 shows that increased investments in manufacturing M&As have a positive impact on relative profitability (b=5,71 p< 0.001) while sustaining increased numbers of manufacturing alliances was found to have a negative effect (b = -67.84 p< 0.001).

Hypothesis 1 predicted that suppliers with an increased focus on modular components manufacturing would reap increased value capture. The results do not support this direct relationship revealing that suppliers, just by having an increased focus on modular products in their portfolio, are not able to convert this strategy into increased levels of value captured. On the other hand, modular innovation effect on relative profitability is significant and positive (b = 56.10 p< 0.05). This indicates that suppliers with greater focus on modular product’s innovation have been able to leverage their bargaining power over

OEMs and increase value capture in their sectors, thus supporting hypothesis 2. In model 3, the results confirmed that increased investments in upstream integration through M&As lead to a higher value capture from modular products ($b = 1830.8$ $p < 0.001$), which supports hypothesis 3. With regards to hypothesis 4, which predicted that increased levels of manufacturing strategic alliances would benefit suppliers’ value capture, it is possible to observe that it actually has a negative and significant moderating effect. Thus, hypothesis 4 was not supported. Finally, with regards to the moderating effect of sustaining a close relationship with downstream buyers, the results reveal that it has a positive impact on suppliers’ capacity to increase value capture from modular products ($b = 52.02$ $p < 0.01$) and support hypothesis 5.

Table 1: Correlations table for suppliers’ dataset

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) Relative Profit.																
(2) Age	0.07***															
(3) Size	0.83***	0.11***														
(4) Leverage	-0.02	-0.02	-0.01													
(5) Export int.	0.22***	0.10***	0.25***	0.02												
(6) R&D int.	0.02	-0.02	0.02	-0.03	0.08**											
(7) Innov. outp.	0.45**	0.02	0.54***	-0.02	0.07**	0.03										
(8) Non-Manuf M&As	0.27***	0.04*	0.28***	-0.01	0.08**	0.00	0.08**									
(9) Non-Manuf Allianc.	0.03*	0.00	0.02	0.00	-0.01	0.00	0.03***	0.07**								
(10) Past perfor.	0.93***	0.06**	0.83***	-0.02	0.23***	0.02	0.44***	0.28***	0.02							
(11) Netw. Cent.	0.13***	-0.04*	0.18***	0.03	0.04*	0.06**	0.05*	0.01	0.00	0.13**						
(12) Struct. hole	-0.10***	0.00	-0.07**	0.01	-0.03	0.00	-0.06**	-0.08**	-0.02	-0.10**	-0.09**					
(13) Upst. M&As integration	0.38***	0.04*	0.36***	-0.02	0.11**	0.00	0.13**	0.36***	0.01*	0.34***	0.02	-0.07*				
(14) Upst. Allianc. integration	0.21***	0.02*	0.23***	-0.01	0.04*	0.00	0.10**	0.22***	0.09**	0.18**	0.168**	-0.06*	0.29***			
(15) Downst. Allianc.	0.17***	-0.01	0.16***	-0.03*	-0.01	0.01	0.07**	0.03*	0.04*	0.17**	0.14**	-0.06*	0.02	0.13**		
(16) Mod. Prod.	0.04*	0.03	0.08**	0.03	0.09**	0.12**	0.04*	0.01	0.00	0.04*	0.06*	-0.01	0.02	0.00	0.00	
(17) Mod. innov.	0.07**	-0.01	0.09*	0.05*	0.09**	0.01	-0.01	0.01	0.00	0.07**	0.07*	0.00	0.01	0.02*	0.00	0.06**

N = 1490, * p <05; ** p <01; *** p <001.

Robustness Tests

I ran different alternative models in order to test the robustness of the results. I substituted the dependent variable relative performance using Ebitda to relative performance using gross profit and net income. In both cases all relationships were supported in the same magnitude and direction. Given the fact that automotive suppliers rely heavily on sales to OEMs, I also substituted the dependent variable by the count of all supply agreement deals of a given supplier in a given year. I tested this model using a panel negative binomial regression and all hypothesis were supported using this approach. Additionally, in order to capture differences related to country of origin, given that automotive players from Japan are known to have a more closed and stable relationship with suppliers (Dyer & Nobeoka, 2000), I ran the proposed models controlling for country of origin using generalized estimating equations (GEE) (Ahuja & Katila, 2001; Liang & Zeger, 1986).

Table 2 – Fixed effects panel regression model

	Model 1		Model 2		Model 3	
Dependent Variable: Relative Profitability	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.
Age	-12.824*	(6.565)	-17.024**	(6.548)	-16.561**	(6.201)
Size	0.009***	(0.002)	0.009***	(0.002)	0.010***	(0.002)
Leverage ratio	0.044	(0.052)	0.050	(0.050)	0.147**	(0.048)
Export Intensity	-41.976	(70.884)	-30.018	(69.522)	-55.541	(65.900)
R&D Intensity	657.538	(892.890)	614.537	(863.380)	795.697	(817.543)
Innovation output	0.191	(0.196)	-0.164	(0.221)	-0.220	(0.213)
Non-Manuf M&As	-132.32***	(32.888)	-135.456***	(33.139)	-108.62***	(31.456)
Non-Manuf Alliances	22.667	(158.100)	36.387	(152.862)	24.452	(144.732)
Past Performance	0.557***	(0.028)	0.564***	(0.029)	0.597***	(0.027)
Network Centrality	-1401.790	(1148.79)	-1489.680	(1131.830)	-1915.800	(1077.92)
Structural Hole	310.78***	(71.602)	286.26***	(69.478)	262.04***	(65.813)
Upstream M&As integration			5.711***	(1.607)	8.418***	(1.546)
Upstream Alliances integration			-67.842***	(14.861)	-108.08***	(14.480)
Downstream Alliances			234.260	(215.236)	559.83**	(208.228)
Modular production Intensity			-29.365	(68.308)	-191.564**	(71.344)
Modular innovation intensity			56.106*	(23.094)	42.735*	(21.886)
Mod. Int. * Downs. All.					52.027**	(21.190)
Mod. Int. * Upst. All.					-3376.6***	(292.847)
Mod. Int. * Upst. M&As					1830.8***	(3103.05)
Constant	686.633*	(477.564)	978.838*	469.431	894.95*	(444.575)
F value	58.030		43.640		48.830	
R-sqr (within)	0.332		0.359		0.427	

N = 1490, * p <05; ** p <01; *** p <001.

This equation allows for the inclusion of dummy variables such as country of origin as it is based on the correlation matrix and accounts for overdispersion and serial correlation in a longitudinal dataset. I coded for firms originated in North America, Japan, Asia and

Europe as these regions encompass all firm nationalities sampled. No significant differences in relative performance were found across different nationalities.

DISCUSSION

This study provides evidence that suppliers increasing focus on complex components such as modules need to develop complementary capabilities in order to capture value from these products. Developing more innovative complex systems in terms of modular components was found to significantly increase suppliers' value capture in comparison to competitors. This finding suggests that although complex products have an increased value perception, capturing value from them requires that firms innovate and protect its modular technology against copy thus limiting substitutability. This study also highlights that suppliers need to properly manage their integration decision in order to increase value capture. Scholars have noted that automotive module suppliers encounter many challenges in adapting their products to the many different car makers and models with different design specifications (Jacobides et al., 2015). Moreover, OEMs are very cautious and secretive when working together with suppliers in the design of new products in order to avoid knowledge expropriation. In this case, although module suppliers have superior capabilities to manufacture complex products with increased added value, their capacity to appropriate value can be hampered due to costs of redesign and redeployment (Fourcade & Midler, 2005).

Therefore, suppliers' difficulties to capture the value created from modular products are overcome when suppliers increase their downstream integration in the form of strategic alliances. The sample indicates that module suppliers with increased value capture have many strategic alliances with their buyers, which are used to strength the relationship increasing trust, transfer of tacit knowledge and reducing costs (Dyer & Hatch, 2006). For those reasons it becomes clearer that a close relationship with downstream buyers is important for value capture from complex products such as modules (Kotabe, et al., 2007). Moreover, this study supports from a global perspective similar conclusions from previous research such as Lazzarini *et al.*, (2008) which found that automotive suppliers would need to explore even more their inter-organizational relationship in order to learn from each other and improve their response to changing market demands. Interestingly, upstream integration was found to have contrasting effects of value capture depending on whether it is through M&As or strategic alliances.

The results provide evidence that suppliers integrating their manufacturing activities through M&As have a superior value capture from modular components while suppliers increasing the number of manufacturing strategic alliances are negatively impacted in their capacity to increase value capture from modules. This finding confirms predictions that firms manufacturing complex products are more successful when they own and control the manufacturing process (Novak & Eppinger, 2001; Perona & Miragliotta, 2004). Particularly in the automotive industry, module suppliers have on average over 80% of components manufactured in house (Fourcade & Midler, 2005), which is important for firms capacity to innovate, upgrade and adapt their components with more flexibility and with less risk of knowledge expropriation. Thus, the benefits of controlling upstream manufacturing capabilities are found to be crucial for suppliers' capacity to successfully manufacture and capture value from their modular products.

Lastly, the negatives effects of increased alliance portfolio can be related to the increased transaction costs coming from too many relationships to be managed at the same time. Coordination and monitoring costs can take a toll on firms' capacity to profit while joint operations also incur in risks of knowledge expropriation (Coase, 1937; Jacobides & Winter, 2005; O. E. Williamson, 1983). Module manufacturing is a complex activity that requires superior integrating and coordinating capabilities to put together different parts and technologies. Managing module components manufacturing through many difference alliance partners can be costly and risky due to challenges arising from the assembly complexity and property rights management. On a related note, scholars have found that in more mature industries where innovations and property rights are more enforceable, firms are more likely to vertically integrate both through own-production and vertical mergers (Fresard, Hoberg, & Phillips, 2013b). In these industries, since firms have more legally enforceable rights of control, they are more likely to merge because patents and property rights can be sustained as source of competitive advantage. Thus, this study complements this perspective and demonstrates that manufacturing integration via M&As is a preferable strategy for suppliers in the automotive industry. It also expands the understanding of how firms appropriate value from modular components from a large-scale and global perspective.

Managers can acknowledge from this study how important it is to integrate manufacturing operations and downstream collaborations in order to leverage value capture from complex products. The findings can also inform managers on the importance of innovating and protecting modular technologies as a crucial activity to remain competitive and create more value than competitors in the industry sector. Moreover, this study also provides evidence that managers of component manufacturing firms should be cautious about increasing its manufacturing alliance portfolio since it can result in increased costs of coordination and monitoring that would ultimately reduce firm’s capacity to capture value from its products. This study has limitations that are worth mentioning. First, it is focused on a single industry and from a suppliers’ perspective which means that findings’ generalizations should consider this aspect. Second, although I only accounted for M&As and strategic alliances with explicit indications that they were manufacturing-purposed, it is difficult to probe all firms’ objectives in engaging in such activities. Yet, patents are more relevant in certain industries than others due to conditions like product/market evolution, complexity and property rights enforcement (Orsenigo & Sterzi, 2010) and future studies should consider such features

CHAPTER IV

New Wine in Old Bottles? The Effects of Product and Process Redesigns on Product Failure and Quality Reputation

Product manufacturing industries have been under great pressure to launch new and more innovative products at increasingly faster rates. Firms from mobile, computer and automotive industries have created a system of new product introductions that is moved by pressures to exceed the already great expectations of consumers. This also shapes firms' upstream activities which are challenged to develop new and more complex products in compressed time spans. In this context, scholars have found that product redesigns and manufacturing upgrades are important sources of competitive advantage in the marketplace (Benner & Tushman, 2003; Katila & Ahuja, 2002). In contrast to entirely new products, redesigns are more common and less risky investments that upgrade previous models with new features. Interestingly however is that although scholarly attention has been drawn to product development speed and capacity to change as drivers of competitive advantage (Kessler & Chakrabarti, 1996; Lieberman & Montgomery, 1988), there is still little evidence on how redesigns affect product failure rates and quality reputation. Moreover, the literature is silent on how previous experience with product failures influence quality reputation. Thus, I question what is the impact of increased product, process and supplier changes on product failure rates? Are firms able to increase quality reputation by augmenting product redesigns and learning from past experience with product failures?

From a strategic management perspective, the investigation of industry and product rates of change is highlighted in the clockspeed framework (Fine, 1998). Industry clockspeeds are seen as the rate of change in product lifecycles and scholars have noted that product and process clockspeeds (i.e. increased changes in products and processes) have a significant impact on the behavior and performance of incumbent firms (Fine, 1998; Mendelson & Pillai, 1999; Nadkarni & Narayanan, 2007). Moreover, I see that technology-based industries with faster clockspeeds (e.g. computers, microprocessors and mobile devices) are capable of accelerating the rate of change in slower clockspeed industries. For example, technologic advancements in infotainment, wireless connectivity and electronic sensors have permanently impacted the automotive industry. Such fast-paced technologies are not only shaping consumers' preferences but also have caused automakers to reduce their product lifecycles in about 25% during the last decade (Roland Berger, 2012). Automakers in turn have been challenged to update their long time established activities with new technologies stemming from high-tech industries. Given the great complexities involved in the manufacture of automobiles, it is not surprising to see a great rise in the number of recalls, which reached a historical peak in the US in 2015. By acknowledging the important strategic implications of managing product failures to the overall performance and reputation of organizations (Kalaignanam, Kushwaha, & Eilert, 2013; Rhee & Haunschild, 2006), this study attempts to fill a gap in the literature by investigating how increased product, process and supplier changes affect product failure rates, and how firms manage product redesigns and learning from past product failures to increase quality reputation.

I chose the automotive industry as the focal industry given its increased exposure to new technological advancements that have pushed automakers to significantly reduce their product lifecycles and accelerate manufacturing processes. The automotive industry also provides a good context for exploring the effects of product and process changes on quality reputation as final consumers have increased their reliance on quality reports to make purchase decisions (Blonigen, Knittel, & Soderbery, 2013; Rhee & Haunschild, 2006). In order to understand how faster clockspeeds influence product failure and quality reputation, I explore the underlying mechanisms of manufacturing complex products such as automobiles. The surge in automotive recalls in the past few years has been attributed to not only increased institutional pressures for safety but also to increases in the number of new features launched by automakers in response to demands for more technologically advanced, environmentally cleaner and fuel efficient vehicles (Bomey, 2016). These pressures for constant changing are also related to product failure, which in turn harms product quality assessments (Rhee & Haunschild, 2006). Therefore, automakers have the challenge to keep up with market demands in order to gain market share and at the same time have their manufacturing activities capable of constant updating without increases in product failure. I theorize that increased product and process changes cause firms to incur in more failure rates stemming from not only assembly processes but also outsourced components. Drawing from the clockspeed and knowledge based perspective, I address issues of learning related to increased rates of change. On the other hand, I highlight that more changes in terms of product redesigns can be seen as a competitive advantage leading firms to meet their customers needs and increase quality reputation. Lastly, I extent the concept of volition in learning by arguing that past experience with product failures voluntarily recognized in-house provide better quality reputation outcomes than experience with product failures recognized by third parties.

In the auto industry, although the development and launch of final products is the result of intense interactions between OEMs and their first tier suppliers, the credits (or blame) of (un)successful products are virtually completely attributed to the OEM. Automakers bear full legal liability for vehicles sold, being responsible for any component or technical failure related to a crash, independently if the failed component was manufactured in-house or acquired from a supplier (Jacobides et al., 2015). Thus, the market perception of quality and performance of an automaker is inseparable from its suppliers'. In this case final product manufacturers can have a negative performance assessment caused by a supplier's defective input (Chao, Iravani, & Savaskan, 2009; Chen, 2005). Many real world cases such as Chipotles' issue of contaminated food, Takata's massive airbag recall and Lenovo recall of computer batteries defectively manufactured by Sanyo, demonstrate that this phenomenon is pervasive across different supply chains and has incurred in substantial costs to these firms. By noticing that product failures can be attributed to assembly or manufacturing defects, the investigation takes into consideration the cases of product failures caused by both assemblers' in-house operations and supplier' component defects.

This study provides theoretical contributions to the understanding on how firms deal with increased pressures for product change and how manufacturing process and supplier changes affect product failure rates. Moreover, it expands organizational learning developments by highlighting the role of volition on learning from past failures and its effects on quality reputation. The findings indicate that models going through redesigns have more defects caused by assembly issues and more defective outsourced components. Increased changes in manufacturing processes are also positively related to product defects caused by both automakers and suppliers. Moreover, I found that supplier changes increase failure rates in outsourced components. This indicates that in complex product industries such as automotive, firms find it very difficult to increase product changes without incurring also in more product failures. The results also highlight the importance of strong supplier involvement and integration as a means to reduce product failure rates. This study also demonstrates that quality reputation is better assessed by consumers when manufacturers invest more in model redesigns. Yet, it shows that experience with voluntary recalls helps firms to learn how to improve their new products and increase quality reputation. These findings indicate that increased rates of change in product redesigns have a dual role on product quality. On the one hand, product redesigns are more susceptible to failure but firms with the capacity to launch more redesigns are also better able to increase brand quality assessments, thus demonstrating that firms can learn from past failures and use it to improve new product developments. However, the results highlight that only firms with increased past voluntary recalls are able to translate this learning into subsequent better quality reputation while firms with increased past involuntary recalls incurred in subsequent negative quality reputation.

THEORY DEVELOPMENT

Clockspeed and Product Redesign

The notion that industries vary from periods of technological stagnation and saturation to periods of fast product changes spurred by innovation is not new. Since (Schumpeter, 1942) work, scholars have explored how industries are shaped by innovation in products and processes as organizational forms and vertical integration are also overturned (Argyres & Zenger, 2012; Langlois & Robertson, 1992). Fine (1998) posits that industries differ in their evolution process and, inspired by biology studies on life cycles, termed industry clockspeed as the rate of change in product life cycles. The clockspeed perspective encompasses the main attributes of industry dynamics and focuses on technologic innovation and competition as the drivers of increased rates of change in products. Thus, scholars have noted that pressures for more innovative solutions end up shaping firms' new product development endeavors and competitive strategies (Christensen, Verlinden, & Westerman, 2002; Jacobides et al., 2006). According to Fine (1998), the clockspeed perspective adds to the literature by focusing on different firm level assets and capabilities utilized for (temporary) competitive advantage. In this study, I borrow from the clockspeed perspective the notion that shorter product lifecycles require firms to increase product changes in order to attain temporary competitive advantages (D'Aveni, Dagnino, & Smith, 2010).

Industries vary from slow (e.g. aircraft) to moderate (e.g. automotive) and fast (e.g. cell phone) clockspeeds. The main determinants of industry change stem from technological and economic shocks that overturn business models, customer preferences and product usefulness. Yet, we should note that fast-paced industries can also influence slow clockspeed industries. Specifically, in the case of high-tech industries such as computer, mobile and microprocessor, their technologic advancements have not only spurred innovation in other industrial sectors but also created opportunity for new players to compete and replace slower, inefficient competitors. The automotive industry provides a good example of how high-tech developments can significantly influence market demands and change product clockspeeds across different industries. Established automotive players such as Ford, GM and Toyota have a history and reputation build upon early developments in automotive manufacturing. This also means that these firms have strong path dependencies related to manufacturing processes and overall supply chain management. Although the automotive industry has evolved in terms of more flexible and modular manufacturing and in terms of fuel efficiency and safety aspects, I observe that given the age of this industry in comparison to other industries such as computer, telecommunication and even home appliances, cars did not change much from what they used to be forty years ago (Jacobides et al., 2012). However, it is possible to observe that in the last decade cars have been increasingly transformed into "computers on wheels", which in turn has drawn the attention of tech giants such as Apple and Google which have recently initiated their own automotive projects with the intention to transform cars in their "ultimate mobile device" (Bradshaw, 2015). By looking at how higher Tesla's stock prices are currently traded in comparison to established players (in 2015 Tesla's price to sales ratio was about 8.15 while Fords' was 0.45), it is clear to see that the market is betting heavily on high-tech cars as the future of individual passenger transportation. This also raises the question on how will established long time players react to such changes? Current data on patent applications regarding autonomous driving technology, telematics and driver assistance shows that from 2010 to 2015 established players such as Toyota, Hyundai, GM and Daimler are actually leading the way against other high-tech firms such as Google (Reuters, 2016). This information reveals that established players are very aware of the future changes in automotive and are acting to update and protect their technologies accordingly.

Blonigen et al., (2013) study on automotive model redesigns provides evidence that automakers, despite the high costs involved, are able to increase profits by constantly introducing redesigned models with new features that are highly appreciated by consumers. Yet, in the case of durable goods such as cars, secondhand sales will increasingly erode current product demand (Blonigen et al., 2013; Esteban & Shum, 2007) which in turn incentivize manufacturers to constantly redesign their models. However, product redesigns also requires substantial coordination of suppliers and manufacturing processes. Scholars have regarded supply chain management as the most important capability in the context of constant changing since firms need to rely heavily in their upstream activities in order to successfully redesign their products and innovate (Fine, 1998; Hult et al., 2007). By noticing that successful product redesigns are of crucial importance to automakers' long term viability and that product failure is a major threat to redesign success and quality reputation, I explore how increased rates of product, processes and supplier base changes can impact product failure and quality reputation.

Scholars have used the clockspeed perspective to understand how firms develop strategic schemas, engage in strategic alliances and launch new products (Guimaraes, Cook, & Natarajan, 2002; Nadkarni & Narayanan, 2007; Parente & Geleilate, 2015). However, the understanding on how increased rates of change in products and processes affect product failure and quality reputation is still missing in the literature. At the firm level, the clockspeed concept is detailed in terms of product, process and organizational. Product clockspeed is observable in product/innovation rates of change. Process clockspeed is captured by internal process adjustments and capital equipment obsolescence rates while organizational clockspeed is seen as the rate of organization restructurings such as CEO turnover and mergers and acquisitions (Fine, 1998). Drawing from this framework, I focus on product and process changes coupled with supplier base change and their effects on product failure as these activities are closely related to product development and quality features. On the other hand, since I look at these change rates effects on assembly and component failures, I also analyze how increased rates of change coupled with different root causes of product failure affect quality reputation.

The following hypothesis development depicts first the role of increased product, process and supplier changes on product failure rates. Next, I also theorize that brand quality reputation is impacted by product redesigns and that voluntary and involuntary recall initiations can have different learning effects which in turn influence quality reputation.

Redesign Changes and Product Failure

Redesigns have become a necessity in complex product industries. Firms are pressured to introduce newly redesigned models in attempts to anticipate competitors' moves and increase market share. Product redesigns are made with the main purpose of updating and upgrading current products with new features and design characteristics accordingly to customers' demands. In contrast to entirely new products, redesigns are more frequent and less risky investments. In the automotive industry, redesigns have become one of the main determinants of firms' success or failure. The average time of model redesigns has been around 6 to 8 years but more recently automakers have reduced most of their model redesigns to periods of 4 to 6 years (Blonigen et al., 2013). Although manufacturers do not follow a rigid schedule for their model redesigns, it is known that automakers work with a “planned obsolescence” for their models since secondhand sales negatively impact current model-year sales over time (Bulow, 1986). Redesigns in the automotive industry are also very complex since it usually involves changes in manufacturing processes, changes of suppliers and new training for employees. On average, the overall cost for a car redesign is estimated to be around U$ 1 billion (Blonigen et al., 2013). Redesigns in the automotive industry include not only minor design changes but also important modifications in mechanical, safety and technological aspects (Knittel, 2009). For example, drivetrain, transmission and engine are usually upgraded with model redesigns as fuel efficiency improvements, emission regulations and safety features evolve between each redesign period.

Incremental innovations are the main feature of product redesigns (Katila & Ahuja, 2002). Such innovations can be related to improvements in product quality and performance as firms involved in constant innovation development projects benefit from accumulated knowledge and learning that help to further advance time-to-market and process efficiency (Garvin, 1983; Koufteros, Edwin Cheng, & Lai, 2007). Scholarly research has pointed out that firms capable of rapidly changing products and processes in order to predict and/or catch up with market demands are capable of achieving a position of competitive advantage (Blackburn, 1991; Fujimoto & Clark, 1991). Incremental innovations usually incorporate changes from customers’ feedback and correct previous model inefficiencies. Thus, some studies have related product innovation positively affecting product quality (Bayus, 1997; Koufteros et al., 2007; Koufteros, Vonderembse, & Doll, 2002).

However, empirical investigations have also found that new product developments can impose challenges to manufacturing processes which in turn may harm product quality (Sethi, 2013). This is evidenced by the great number of failures and defects related to new product introductions (Cooper, 2001). Innovations such as product redesigns cause disturbance in the already established practices across the manufacturing process. Particularly in highly complex product manufacturing such as automotive, even minor changes can cause a significant impact on assembly operations and overall performance (Fujimoto & Clark, 1991). Scholars also highlight that workers are challenged to learn new, unfamiliar practices in short periods of time when a new product or production method is developed, which in turn can hamper their efficiency since a new frame of mind needs to be established (Lmai, 1986). Thus, Sethi (2000) highlights that new product developments are more prone to cause variations in the production process and hamper product quality. This happens mainly because workers need time and training to learn and apply new knowledge without inertia effects, especially when long time established operations have to be changed (March, 1991; Slater & Narver, 1998). In the case of the automotive industry, old manufacturing standards have been substituted to more modular and leaner operations (Womack et al., 1990). Additionally, increased demands for product redesigns as a result of new technologic developments and customers’ preferences further increase the rate of change in terms of acquiring new knowledge.

Pressures to increase new product development speed are long noticed to negatively affect final product quality (Bayus, 1997). Increased changes in product features in shorter time spans also increases the risks of overseeing important quality aspects since quality tests are reduced (Cooper, 2001). Clark and Fujimoto (1991) concluded from their in-depth study of the automotive industry that a trade-off between overall quality and speed to market exists. That is because pressures for speed and innovation are opposite forces against quality and safety focus (Haunschild, Polidoro, & Chandler, 2015). Thus, firms managing product redesigns in the context of increased time to maker pressures are even more susceptible to be involved in product quality issues.

It is important to discern however that product failure may occur for different reasons. The Consumer Product Safety Commission (CPSC) posits that product failures or defects can stem from manufacturing process, production, design or packaging/warning errors. In the automotive industry, product failures occur mainly due to either manufacturing process (assembly) and design errors or component defects. On the one hand, assembly process errors and design malfunctions are attributed to OEMs fault while component defects are attributed to the assigned component manufacturer which mostly often is a first tier supplier. First tier suppliers have a great share of responsibility in product quality issues in the automotive industry as Ford has reported that about 76% of the company's quality problems come from tier one suppliers (Sherefkin & Armstrong, 2003).

From an assembly manufacturer perspective, product redesigns can significantly intensify assembly and design defects. New design features often interact with previous model characteristics which in turn increases the risk of product failure. Moreover, new designs are also untested in the marketplace under the varied and unexpected ways consumers can make use of the new product. New designs also change previously established manufacturing processes which in turn can generate more oscillation and consequently final assembly errors. Therefore, drawing from the aforementioned issues related to learning and manufacturing adaptation challenges in product redesigns, I conjecture that assemblers are likely to incur in more assembly-related failures when product redesign rates increase.

Moreover, I argue that increased product redesigns will also be related to more component defects originated from suppliers. In order to understand how model changes influence outsourced component failure rates, it is important to highlight how OEMs establish their contracts and operations with suppliers. In the automotive industry, OEMs decide their supply contracts through competitive bidding and develop specifications for each model regarding the outsourced component including detailed aspects such as design, type of material and other specific features. Automotive supply contracts are a classic example of the “hold up” problem since they are established with long term aspirations and usually require heavy investments in machinery, plant location and overall assets specificity (Coase, 2000). On the one hand, OEMs look for ways to have outsourced components with great levels of technologic development and quality for each of its models, while on the other hand, suppliers look for ways to develop superior and unique products that can be standardized and easily redeployed across different makers and models (Fourcade & Midler, 2005). Scholars have noted that OEMs have the upper hand when contracting with suppliers and usually force them to comply with their requirements regarding product quality and price (Ben-Shahar & White, 2006). This situation has been argued to be one of the main reasons why OEMs keep most of the value capture in this industry (Jacobides et al., 2015). Supplier facing increased product redesign requests will have the challenge to adapt their components to many different model-specific requirements. Thus, OEMs with greater numbers of redesigned models will also have to deal with more asset-specific and complex relationships with suppliers. Although it is known that OEMs try to establish a close relationship with key suppliers in order to improve its production efficiency and overall product performance (Dyer & Nobeoka, 2000; Petersen, Handfield, & Ragatz, 2005), increased model redesign requests can still significantly challenge suppliers' capacity to deliver updated products at high quality standards. That is mainly because new product requests in the context of compressed time spans directly affect suppliers' capacity to fulfill new design and technological requests on time, which in turn reduce efforts in quality assurance. Moreover, suppliers dealing with more redesign requests at the same time would get into a even more complicated situation since each maker usually has a specific product request for each model. Given the circumstances related to product redesigns and the incidence of defects stemming from assembly and design issues as well as defective components from suppliers, I hypothesize the following:

Hypothesis 1: Firms increasing the number of model redesigns are more likely to have more defects caused by both (a) OEM and (b) suppliers.

Closely related to product redesigns are process redesigns (Utterback & Abernathy, 1975). More specifically in the case of manufacturing processes, these are updated as new methods of production and technological advancements take place in the industry. Scholars have noted that performance and efficiency improvements coupled with cost reductions and new product developments are the main drivers of manufacturing process change (Carrillo & Gaimon, 2000; Gautam & Singh, 2008). Changes in manufacturing process targeting efficiency gains tend to become more important in mature stages of industry evolution. When products are entirely new in the market, firms are still figuring out ways to further improve production methods as innovation and time to market are more important than cost efficiencies (Lehnerd & Meyer, 2011). However when the product is mature, firms will tend to compete for cost reductions mainly via improved manufacturing processes (Langlois & Robertson, 2002; Utterback & Abernathy, 1975). Therefore, improved process manufacturing is expected to benefit firms' overall profitability and capacity to develop improved products (Fujimoto & Clark, 1991).

In the case of the automotive industry, cost reductions in manufacturing processes are a crucial determinant of firms' profitability and survival (Clark, 1985; Fujimoto & Clark, 1991). The automotive industry until the 1970s was characterized by a highly vertically integrated supply chain. During early 1980s however significant changes towards disintegration started to occur. OEMs decided that suppliers should be used for costs reduction while OEMs could focus on their core competencies of assembly, design and engine manufacturing (Abernathy, 1976; MacDuffie & Helper, 1997). The 1980s was also the period when Japanese automakers entered the US and forced American automakers to improve product quality and reduce costs by adopting a leaner manufacturing process with just-in-time operations (Womack et al., 1990). Since then, the global automotive industry has increased its reliance on suppliers as well as leaner and more flexible modular assembly processes. Manufactures have been reshaping their production platforms in order to have a more flexible manufacturing process able to encompass different models and bring together the participation of key suppliers.

Manufacturing process changes require workers to learn new procedures and usually involve the acquisition new tooling and machinery. In the case of lean manufacturing process, it involves also other aspects such as waste management, inventory control, cross-functional teams and a continuous improvement system (Shingo & Dillon, 1989; Womack et al., 1990). Lean and more flexible manufacturing processes have been noted to significantly improve production efficiency and product quality (Levy, 1997; Taj, 2008; K. Ulrich, 1995), however these effects are noted only after the production process has been settled. In the case of changes in manufacturing process, there is still a paucity of research on how it can affect product quality. It is known that when new manufacturing technologies are introduced, workers tend to initially resist and underperform in their activities (Blumberg & Gerwin, 1984) which require firms to invest in "high commitment" human resource practices and extensive training (Garvin, 1983; MacDuffie, 1995). Therefore, new manufacturing processes can cause significant disturbances in how current operations are conducted.

For example, automakers have recently invested billions of dollars in new production platforms capable of assembling an increased number of models with improved technology and flexibility (Klayman & Lienert, 2014). However, these changes also require workers involved in the process to learn new activities and adapt to new design frames. From an assembly standpoint, working in a new platform means that major adaptations will have to be made in the transition from the old method of production the new one. Moreover, newer manufacturing processes such as new automotive platforms tend to be more complex by aggregating more functions, models and teams in order to attain efficiency gains, which in turn become more difficult to manage and coordinate (Mike, Mats, Javier, & Oriol, 2007).

This also indicates that when manufacturing processes such as platforms change, OEMs will initially struggle to adapt its operations and achieve its targeted standards of production and quality. That leads to the hypothesis that when there is a major production process change, firms may become more prone to incur in assembly-related manufacturing defects.

Hypothesis 2: Changes in manufacturing process increase model defects caused by OEMs.

Supplier Change and Product Failure

The decision between manufacturing in-house or outsourcing production has been vastly investigated in the literature (Coase, 1937; Jacobides & Winter, 2005; O. E. Williamson, 1983). On the one hand, vertically integrated operations facilitate learning gains that can enhance the development of know-how and more radical innovations as well as providing firms with less uncertainties regarding production and inventory. On the other hand, outsourcing provides access to products with cutting-edge technologies and better control over costs and quality (Adner & Kapoor, 2010; Rothaermel et al., 2006). It is known that in complex product industries assemblers rely on close and resource-dependent relationships with key suppliers which need to have exclusive access to assemblers' technologies in order to understand their needs and respond quickly to new and constant requirements. The established alternative in the automotive production has been the outsourcing of the vast majority of components. As mentioned earlier, OEMs outsource most of its part production but keep their role of "system integrators" and coordinators of the supply network (Jacobides et al., 2015). Scholars ((Jacobides et al., 2012; Novak &

Stern, 2008) have noted that OEMs have a strong position of bargaining power over the supplier base due to OEMs' requirements of asset specific investments and industry's oligopolistic characteristics. However, it is important to highlight also that OEMs may find it difficult to substitute suppliers since there are no general product standards in the industry which makes OEMs to rely on specialized know-how and customized products from suppliers (Dyer & Nobeoka, 2000; Monteverde & Teece, 1982).

In this sense scholarly research has pointed out that high levels of supplier involvement are necessary for better results in terms of production efficiency, new product developments and financial performance (Dyer & Hatch, 2006; Lakshman & Parente, 2007; Parente & Geleilate, 2015). Supplier involvement is also a fundamentally necessary to support firm operations in times of constant pressures for change (van Echtelt, Wynstra, van Weele, & Duysters, 2008). Firms with strong supplier relations will be better able to develop new products faster since suppliers will be better able to understand product adaptation needs. Moreover, close supplier relations also improve product quality as suppliers are able to access more information from buyers and adjust operations faster based on learning gains developed through clear and efficient instructions (Takeishi, 2001). However, although the benefits of increased supplier involvement are evident, some OEMs may still prefer to work with suppliers using a more "transactional" approach aiming at costs reduction through competitive bidding. Related studies highlight that Asian OEMs, particularly Japanese, invest heavily on supplier involvement and have been able to greatly benefit from it (Dyer & Nobeoka, 2000; Helper, 1991). American OEMs on the other hand are known to have poor supplier relationships (Ben-Shahar & White, 2006; Helper, 1991). Interestingly, recent surveys revealed that not all Japanese OEMs have been able to sustain high quality supply relations as Nissan has scored poorly in the 2015 supplier working relations index (Hedge, 2015). Yet, the survey reveals a converging trend where Japanese OEMs with great supplier relations have been scoring lower since 2007 while American and European OEMs have been steadily increasing their supplier relationship index (Hedge, 2015).

Despite variations across OEMs in their supplier relationships, it is known that all OEMs may eventually incur in supply agreements termination. The main reasons for this are price negotiation disagreements and quality/delivery issues. Supply agreements are usually established in the automotive industry with long term objectives but purchase orders usually have short period terms (Ben-Shahar & White, 2006). That occurs because OEMs avoid to be locked up with a single supplier given the risks involved in production delivery, quality warranties, price renegotiations and knowledge expropriation (Jacobides et al., 2012). Given the high levels of asset-specific investment from the suppliers' end to manufacture components tailored accordingly to OEMs specifications, OEMs may also invest their own capital in suppliers' tooling and raw materials acquisition for example (Dyer, 1996).

This scenario illustrates that buyer-supplier agreements in the automotive industry are complex relationships involving large amounts of capital and commitment from both sides. In this context, OEMs that switch suppliers frequently are mainly looking to reduce their input costs, which generally occurs at the expense of product quality (Helper, 1991). Evidence from the analysis of OEMs' supply contracts shows that OEMs who have more outsourced component defects also have more demanding clauses on suppliers' cost liability (Ben-Shahar & White, 2006). This illustrates that when parties have the capacity to shift the cost of liability onto others (e.g. suppliers) they tend to be less concerned with reducing that cost (Ben-Shahar & White, 2006). It also indicates that OEMs with poor supplier relationships tend to care less about their suppliers' performance since they will prefer to switch them even at the risk of incurring into higher levels of outsourced component failures. Moreover, when OEMs change suppliers for a specific component, the new supplier will have to significantly invest into adapting its product to the new specifications as well as acquiring transaction-specific knowledge on how to integrate its operations in the final product assembly process (Monteverde & Teece, 1982). Even though automotive supply agreements have a high degree of details and performance requirements, many improvements can only be achieved through experience and tacit-knowledge sharing (Aoshima, 2002; Kotabe et al., 2007). Automotive suppliers have also been increasingly taking a more prominent role in part manufacturing, innovation and design (Petersen et al., 2005; Wagner & Hoegl, 2006), being responsible in many occasions for "black-box" and "gray-box" developments. This circumstance enhances even more the difficulties in terms of product development a new supplier may find when getting a new component contract. I therefore expect that supplier changes will increase product failures caused by outsourced components.

Hypothesis 3: Outsourced component failure rates are higher when suppliers are changed than when there is no change of supplier.

Product Redesign and Quality Reputation

As noted previously, managing product and process changes in complex products such as cars is a very demanding and complicated activity that increase the risk of product failure. But does it pay off? From a financial perspective studies have shown that model redesigns usually generate substantial profits (Banbury & Mitchell, 1995; Blonigen et al., 2013). However investigation on how redesigns impact quality reputation is still scant in the literature. Overall brand reputation has an key role on firm survival rates, consumers' preferences and is referred as an important organizational asset (Fombrun & Shanley, 1990; Rao, 1994; Shapiro, 1983). Reputation allows firms to charge higher prices, increase sales, repel new entrants and achieve higher levels of financial performance (Milgrom & Roberts, 1982; Podolny & Phillips, 1996; Shapiro, 1983). The concept of reputation has been investigated from different perspectives. Some studies have focused on the sociological aspects of reputation such as public's cumulative judgment of firm behavior over time (Podolny & Phillips, 1996; Rindova, Williamson, Petkova, & Sever, 2005). Others have focused on the economic and marketing side of reputation such as expectations of quality, brand image, status and prestige (Blau, 1964; Rindova et al., 2005). Given this study's objective of understanding the effects of product and process change on quality-related issues, I approach brand reputation as an attribute of customers' quality assessments, namely, quality reputation (Rhee & Haunschild, 2006; Shapiro, 1982).

There are innumerous reasons why firms change their products' design. Redesigns are made to update product's shape and features accordingly to current demands, upgrade functions and correct for quality issues or to copy and catch up with competitors' new developments (Debruyne et al., 2002; Hadjinicola & Kumar, 2005). Customers usually attribute greater value to redesigned models and competition created over new model launches is conducive of faster rates of change. Thus, it is widely known that firms launching new products first also reap a greater market share (McNally, Akdeniz, & Calantone, 2011). Developing new products and launching them first in the market is also associated with superior levels of firm performance, quality and brand image (Lieberman & Montgomery, 1988; Menon, Chowdhury, & Lukas, 2002; P. Smith & Reinertsen, 1991).

Therefore, firms introducing an increased number of product redesigns are expected to be able to increase quality reputation by constantly meeting their customers' demands (Tatikonda & Montoya-Weiss, 2001). It is true that firms may fail to achieve their desired level of customer satisfaction with new model redesigns. Especially in the automotive industry, redesign failures are very costly and damaging for reputation (Nieuwenhuis & Wells, 2015). However, the primary activity in the automotive industry capable of determining firm survival has been the capacity to successfully introduce new and redesigned models (Fujimoto & Clark, 1991; Pawels, Srinivasan, Silva-Risso, & Hanssen, 2003; Rao, 1994; Womack et al., 1990). Automakers invest billion of dollars on each model redesign since it has a significant impact in their profitability and consumers' utility and value perception (Blonigen et al., 2013; Pawels et al., 2003). Developing more innovative redesigned models allow firms to be a step ahead of competition and increase value appropriation (Slater, 1996; Tatikonda & Montoya-Weiss, 2001). Firms capable of developing an increased number of new model redesigns will be able to accumulate important tacit knowledge and know-how that can be used to further improve new product developments (Helfat & Raubitschek, 2000; Katila & Ahuja, 2002; McNally et al., 2011).

A feedback loop has been noted where successful new product launches increase firm profitability which in turn will be used to further improvements in new product developments (Pawels et al., 2003). Thus, a firm having a increased capacity to introduce more redesigned models will also be better able to have it done more efficiently. This in turn leverages the firm's ability to consistently meet customers' demands, increasing quality reputation (Pawels et al., 2003). Since product quality assessments are based not only on product attributes but also on the relative superiority against alternative substitutes (McNally et al., 2011; Sethi, 2013), firms with more redesigned models do it so to increase their quality reputation (Colias, 2015). This leads to the following hypothesis:

Hypothesis 4: Product redesigns are positively related to quality reputation.

Volition and Quality Reputation

The last hypothesis focuses on the learning aspects related to product failure. Past investigations have found that product failures such as recalls have a negative impact on quality reputation ((Rhee & Haunschild, 2006), sales and stock market reaction (Davidson & Worrell, 1992; Grafton, Hoffer, & Reilly, 1981). Product failures cause disappointments and frustrations on final users and may incur in consumers' harm or lead to fatal accidents in some occasions. Despite the well known negative effect of product failure on quality reputation, less is known on how firms learn from past failures and improve reputation based on voluntary initiatives (Haunschild & Rhee, 2004).

The literature highlights that past experiences with product failure generate important organizational learning and change (Chuang & Baum, 2003; Haunschild et al., 2015). Learning in this case is seen as an organizational process that reacts to past failure experiences and leads to a change in future failure outcomes (Haunschild & Rhee, 2004; Levinthal & March, 1993). Therefore, I assume that organizational learning generates greater favorable outcomes from past experience as well as a reduction in unfavorable ones (Lave & March, 1993; Levitt & March, 1988). Studies have found that greater experience with production and past recalls is associated with greater accumulated knowledge and organizational learning which in turn reduces future recalls (Haunschild & Rhee, 2004; Kalaignanam et al., 2013). Less in known however if there are differences in the learning process from past experience with product failures detected by voluntary or involuntary investigations. Haunschild and Rhee (2004) found that firms learn better in response to voluntary internal procedures instead of external mandates and that firms with more voluntary initiatives to resolve recalls are able to reduce subsequent recall rates while firms responding to more involuntary recalls do not. That is because voluntary initiatives to solve problems are related to an increased commitment to problem solving and learning, while responses to external mandates " … tend to produce defensive reactions that are not coupled to the organization in any useful way" (Haunschild and Rhee, 2004:1545).

I extend this concept and argue that firms with more voluntary initiatives towards resolving recalls will have an increased quality reputation in comparison to firms with less volition on this matter. Firms with more initiative towards problem solving tend to reinforce this behavior at the occurrence of failures and subsequently increase safety standards and reduce future recalls (Haunschild et al., 2015; Haunschild & Rhee, 2004; Marcus & Nichols, 1999). This indicates that firms with more voluntary than involuntary recalls are more aware and investigate more their products' quality standards. On the other hand, studies point out that when external pressures are imposed, people tend to make poorer decisions and resist to change (Fidler & Johnson, 1984; Guth & Macmillan, 1986; Kostova & Roth, 2002). A firm reacting to external mandates on product failures is more likely to just focus on repairing the problem in a defensive reaction, which in turn does not allow the firm to really absorb and incorporate to its routines possible lessons learned from the process (Haunschild & Rhee, 2004; Marcus, 1988). This indicates that firms with better capacity to detect and solve product defect issues internally will have organizational learning gains that help them to reduce future errors and be capable of manufacturing products with better quality. Thus, quality reputation increases as the firm demonstrates to the market that it is aware and responsive for eventual product failures. In fact, studies have shown that automakers may initiate a recall just to indicate that they are paying attention to product quality, and that sales increase with such non-severe recalls (Rhee & Haunschild, 2006). I thus propose that past voluntary recalls, in contrast to involuntary ones, not only reduce future recalls but help firms to enhance the overall quality of their products which in turn is reflected in higher quality reputation assessments.

> *Hypothesis 5: Past experience with voluntary recalls has a more positive impact on quality reputation than experience with involuntary recalls.*

METHOD

Sample

The US automotive industry was chosen as the context for the empirical investigation. The US is the second largest and most competitive automotive market in the world having a great diversity of makers and models. All automakers that participated in this marketplace during the sampled period having considerable size and visibility were included (Andrevski, Brass, & Ferrier, 2013). The list is composed by: BMW, Chrysler, Daimler, Fiat, Ford, General Motors, Honda, Hyundai, Kia, Mazda, Mitsubishi, Nissan, Subaru, Toyota and Volkswagen. These automakers are responsible for around 95% of total vehicles sold in the US (Kalaignanam et al., 2013). Following past research on recalls (Haunschild & Rhee, 2004; Rhee & Haunschild, 2006), I focus on automaker's brand (e.g. Chevrolet, Lexus) instead of parent firm. That is because it is known that automakers have their new product development teams and R&D efforts made separately for each brand (Haunschild & Rhee, 2004) and brand reputation assessments are also made independently. The sample period covered is from 2007 to 2014. This period includes the phase in which automakers started to include more high-tech features in their models such as wireless connectivity and parking assistance (Viereckl, Ahlemann, Koster, & Jursch, 2015). It also encompasses a time where there has been a great surge in automotive recalls in the US (D. Levin, 2015).

Recalls information was retrieved from the National Highway and Traffic Safety Administration (NHTSA). This institution provides all recalls information in the US since 1967. The NHTSA establishes safety and performance standards that all automakers commercializing vehicles in the US must comply. Automakers have to inform all recalls to NHTSA, however the institution also investigates cases of owner complaints and has its own test facilities to independently conduct vehicle investigations. Recalls from the NHTSA are reported with many important information such as maker, model-year, description of defect, recall initiator (automaker or government), and time period in which the vehicle was manufactured. I noted that the NHTSA recalls database may duplicate a recall record if the issue involving the recall is related to more than one vehicle-component group. For example, a recall of an electrical issue with the tire pressure monitor system for the same maker, model and year was found to have a record within the component group "tire pressure monitor system" and another record within the component group "electrical system". Therefore, when facing duplicated records, I retained only the record that more accurately identify the component issue, in the aforementioned example, the "tire pressure monitor system". A total of 33 automaker brands were responsible for 2074 unique recall records during the sampled period.

Firm-level information was gathered from multiple sources. Financial information was obtained from Bloomberg and complemented with COMPUSTAT and Orbis databases. Deals data regarding M&As and strategic alliances was gathered from SDC Platinum and also from companies' websites and fillings such as 10-K. Patent information was obtained from the USPTO. Lastly, automakers and models information regarding production, sales, changes in model and platforms as well as buyer-supplier agreements were gathered from the Marklines database.

Dependent variables

Since the objective is to assess the impact of changes in model, manufacturing process and suppliers on product failure rates stemming from different sources, I had to establish a procedure to identify the product failure source for each recall. According to the Consumer Product Safety Commission (CPSC), product failures can stem from manufacturing process, production, design or packaging/warning errors. In the automotive industry, recalls are usually caused by either manufacturing process (assembly) and design errors or defective component. Assembly and design are known to be of the automaker's responsibility while components can be produced in-house by the automaker or outsourced to a first tier supplier. In order to categorize the recall source as either OEM-related or supplier-related, I initially read carefully each recall "defect summary" section and identified the source of failure as being related to an assembly error (e.g. installation error or misplaced component), design error (e.g. fuel tank design), or component defect (e.g. airbag malfunction or transmission failure). Assembly and design errors were considered as OEM failure (Hora, Bapuji, & Roth, 2011). Defective components were checked in the buyer-supplier agreements dataset if manufactured in-house or outsourced to a supplier. We were able to retrieve information of 91% of product manufacturers of defect components. All recalls related to a defective component manufactured by a supplier were considered as supplier failures. This process was undertaken by two coders and the inter-coder correlation was 85%. All inconsistencies were resolved by the research team. Thus, OEM-related failure was measured as the total number of recalls attributed to assembly/design errors from 2007 to 2014. Supplier-related failure was measured as the total number of recalls attributed to outsourced components defects from 2007 to 2014.

Hypotheses 4 and 5 focus on the effects of product redesigns and learning from past failures on quality reputation. Scholars have found from interviews with automotive industry specialists that third-party ratings are a valid and valuable source of information that shape customers' assessments of quality (Devaraj, Matta, & Conlon, 2001; Levin, 2000; Rhee & Haunschild, 2006). Yet, experts have also acknowledged that J.D Power and Associates ratings are the most influential in the US (Rhee & Haunschild, 2006). I therefore chose as the quality reputation measure the J.D Power and Associates' Initial Quality Study since it captures vehicle owners' complaints regarding design and components problems encountered during the first 90 days of ownership for a current model year. This index is reported as the total number of problems per one hundred vehicles which means that less is better. I reversed this index in the analysis in order to facilitate interpretations.

Independent variables

Model redesigns are strategic, costly and engineering-intensive endeavors that receive a great amount of attention from the media (Blonigen et al., 2013). Redesigns are characterized by substantial design changes and also carry many internal modifications in contrast to facelifts which usually include minor design changes and features introduction (Blonigen et al., 2013; Knittel, 2009). In order to capture the effect of more profound changes, I only considered complete model redesigns in the measurement of product redesigns and model change. Model redesigns was measured as the average number of model redesigns launched over the past three years. Using the average allows the capture of model redesigns more evenly across different makers since redesign launches vary each year for different makers and makers also do not launch all redesigns in the same year.

With regards to process changes, I focus on platform changes since platforms concentrate the main manufacturing process activities involved in vehicle production. Platforms are complex systems involving assets, processes, teams and relationships in which different models sharing the same structural frame (e.g. chassis and engine) are assembled (Robertson & Ulrich, 1998). The objective of a platform is to have the greatest number of models sharing the maximum number of parts in order to optimize economies of scale and scope (Weber, 2009). A platform change means that a new manufacturing method will be applied including new and more advanced technologies and that more models will be added to the system, increasing system complexity (Mike et al., 2007). Therefore, a change of platform in the automotive involves a significant change in the manufacturing process. Since firms learn from past experience how to fix and improve their operations (Levinthal & March, 1993), I focus on the immediate impact of process change on product failure. Thus, process changes was measured as the total number of models that have gone through a manufacturing platform change in the year of its manufacturing.

I measure supplier change effects on product failure at the product level. That is because the objective is to determine if supplier-related recalls are increased when there is a change in the supply agreement for a given component. Supplier change was measured as the total number of recalled vehicles that had a defective outsourced component in which the supplier has been substituted. Lastly, I measure Voluntary recalls as the total number of recalls reported in the NHTSA database being initiated by the automaker. Involuntary recalls was measure as the total number of recalls being initiated by NHTSA’s office of vehicle safety compliance or office of defect investigation.

Control Variables

Several control variables are included in the order to ponder the effect of alternative factors influencing automotive recalls and quality reputation assessments. Firm experience is known to affect firm learning and performance (Levin, 2000). I control for firm experience using automaker's age as proxy. Studies on the automotive industry have pointed out that Asian firms are usually more efficient and have more reliable products in contrast to other nations. I control for nationality differences by creating a dummy variable controlling for Asian automakers (in this sample, Japanese and Korean) and a dummy variable controlling for European automakers in order to contrast against US firms. Studies investigating automotive recalls have also noted differences between "generalists" and "specialists" automakers. Generalist automakers are those with increased product portfolio and larger manufacturing capabilities, while specialists are those who focus on a niche market and have fewer model variants. Following Haunschild and Rhree (2004), I measure generalism/specialism using a continuous variable measuring the spread of engine capacity for each automaker. This is calculated by having an automaker's largest engine capacity subtracted by the smallest one. Firm innovation focus has also been noted to oscillate in times of serious errors (Haunschild et al., 2015) and was measured as the automaker's' total count of successful patent applications. Lastly, I control for firm size since it has been noted to influence firm learning and recall rates (Haunschild & Sullivan, 2002; Kalaignanam et al., 2013). Size was measure as the automaker's total units sold in a given year.

Analytical Procedure

This study has an unbalanced, pooled, time-series data which requires estimation that is appropriate for its longitudinal structure. I observed that independent variables are likely to incur in serial correlations and firm-specific heterogeneity is also present. I also tested for the preferred approach between fixed and random effects using Hausman's test and the results was non-significant in the case of count (recalls) dependent variable, indicating the use of random effects estimation. Thus, generalized estimating equations (GEE) was selected as the estimation that best fits the data structure and analysis (Dobrev, Kim, & Carroll, 2002; Gardiner, Luo, & Roman, 2009). This method allows the specification of a correlation matrix to account for within-subject correlations, heteroscedasticity and unobserved differences among firms (Gardiner et al., 2009). Because I have two different types of dependent variables, different distributions were utilized. For count dependent variables total OEM-related failure and total supplier-related failures, a negative binomial distribution was used due to over dispersion encountered. For the quality reputation dependent variable, a Gaussian distribution was used. All variables were lagged one year with the exception of model redesigns, process change and supplier change. These variables are not lagged because model redesigns, platform changes and supply agreement changes are measured based on the the model-year after the change, meaning that the change occurred in the year before. Since the recalls dependent variables are based on the year of manufacturing of the vehicle (occurrence of the event), the objective is to analyze if the problem that generated the recall occurred during the manufacturing of the vehicle. Variance inflation factors (VIF) were accounted for each model and do not represent a threat of multicollinearity since they were all below five (Gujarati, 1995).

RESULTS

The analysis testing the effects of product redesigns, process and supplier changes are shown in Table 3. Model 1 assess the effects of control variables on OEM-related recalls. Firm size has a negative and significant effect ($b = -0.0001$, $p < 0.01$) on assembly/design recalls. This indicates that even though the correlation between total recalls and size is positive and high ($r = 0.52$ $p<0.01$) larger firms tend to have less OEM-related recalls. Level of generalism was found have a positive and significant ($b = 0.0001$, $p < 0.01$) effect on OEM-related recalls, thus indicating that since generalists manufacture more models and have more assembly lines, they are more likely to incur in assembly/design errors. Yet, firms with high innovative focus also are more likely to incur in assembly/design errors ($b = 0.0001$, $p < 0.01$), which corroborates the idea that innovation focus increases tensions in the manufacturing process (Sethi, 2013) and decreases safety focus (Haunschild et al., 2015).

Hypothesis 1a predicts that firms with increased number of model redesigns are more likely to have more recalls caused by OEM-related defects. That is supported in model 2 ($b = 0.274$ $p < 0.05$) showing that automakers increasing the number of model redesigns also have higher rates of assembly/design errors. Hypothesis 2 states that changes in manufacturing processes also increase recall rates caused by OEM-related defects. The results confirm that when automakers change product platforms, there is also an increase in assembly/design errors. Models 3 and 4 reveal the effects of control variables and rates of change on supplier-related recalls. Firm age was found to be positively related to outsourced components failure rates (b = 0.020, p < 0.01). Firm size has a negative impact on supplier-related defects.

Table 3 - Estimates results for recalls

Dep. Variable	OEM-related failure		OEM-related failure		Supplier-related failure		Supplier-related failure	
	Model 1		Model 2		Model 3		Model 4	
Age	-0.004	(0.009)	-0.004	(0.010)	0.020**	(0.007)	0.019**	(0.006)
Size	-0.000***	(0.000)	-0.000	(0.000)	-0.000***	(0.000)	-0.000	(0.000)
Asian	-0.225	(0.483)	0.481	(0.380)	-0.372	(0.326)	0.322	(0.312)
European	-0.379	(0.263)	0.169	(0.221)	-0.798***	(0.137)	-0.471***	(0.165)
Level of generalism	0.000***	(0.000)	0.000	(0.000)	-0.000*	(0.000)	-0.000	(0.000)
Innovation Focus	0.000***	(0.000)	0.000	(0.000)	0.000	(0.000)	-0.000	(0.000)
Model redesigns			0.274*	(0.128)			0.015	(0.113)
Process changes			0.13***	(0.007)			0.089***	(0.009)
Supplier change			0.074	(0.077)			0.335***	(0.057)
Constant	1.583	(0.902)	0.170	(1.153)	0.036	(0.738)	-1.219	(0.691)
Wald Chi-square	43.160		583.780		87.740		215.840	
D.f	6.000		9.000		6.000		9.000	

N = 250, * p <05; ** p <01; *** p <001

European firms also have less outsourced components failure rates compared to North American and Asian (b = -0.798, p < 0.001). In model 4, independent variable model redesigns is found to have a positive but non-significant effect on supplier-related recalls, thus rejecting Hypothesis 1b. Hypothesis 3 argues that a change of supplier in a given component will increase the rate of supplier-related recalls. The results confirm that hypothesis ($b = -0.798$, $p < 0.001$), thus corroborating the argument that suppliers assigned to a new supply agreement are more likely to incur, at least initially, in higher rates to product failure.

Models 5 and 6 are shown in Table 4 and assess the effects of learning from past recalls and model redesigns on quality reputation. Model 5 includes only control variables and we can see that innovation focus has a positive and significant ($b = 0.009$, $p < 0.001$) effect on quality reputation. Model 6 includes independent variables and shows that increased model redesigns have a positive and significant effect on quality reputation ($b = 8.460$, $p < 0.001$), thus confirming hypothesis 4. Hypothesis 5 stated that past voluntary recalls have a more positive impact on subsequent quality reputation assessments than experience with involuntary recalls. This hypothesis is supported as the effect of past voluntary recalls on subsequent quality reputation is found to be positive and significant ($b = 0.508$, $p < 0.05$) while the effects of past involuntary recalls is negative. I also tested this difference between past voluntary and involuntary effects on quality reputation using a bootstrap procedure and results were significant ($t = 3.46$ $p < 0.001$). Next, I provide information on some robustness test ran and in the discussion section I assess the implications and contributions of these findings.

Table 4 – Estimates results for quality reputation

Dep. Variable	Quality reputation

	Model 5		Model 6	
Age	0.207	(0.217)	0.168	(0.202)
Size	-0.000	(0.000)	-0.000***	(0.000)
Asian	11.821	(9.466)	2.153	(8.825)
European	9.818	(5.530)	4.120	(4.923)
Level of generalism	0.003	(0.002)	0.000	(0.002)
Innovation Focus	0.009**	(0.003)	0.010***	(0.003)
Supplier-related failure	0.262	(0.311)	0.277	(0.307)
OEM-related failure	-0.076	(0.136)	-0.214	(0.165)
Involuntary recalls			-2.743**	(1.060)
Voluntary recalls			0.508*	(0.271)
Model redesigns			8.460***	(2.252)
Constant	-148.279	(23.777)	-140.9***	(21.993)
Wald Chi-square	18.770		52.340	
D.f	8.000		11.000	

N = 250, * p <05; ** p <01; *** p <001

Robustness Tests

Several robustness tests were employed in order to assess the validity and reliability of the methodology applied in this study. Regarding the dependent variable quality reputation, I gathered results from the J.D Power and Associates vehicle dependability study which collects information on vehicle owners experience during the past 12 moths for model years launched 3 years ago. Since this index represents model-years launched 3 years ago, I adjusted the by lagging the independent variables accordingly and then tested models 5 and 6 using dependability index as the dependent variable. The results corroborate the analysis using initial quality as dependent variable with the same significant effects having the same directionality. I also created a composite measure by averaging the initial quality study and dependability study (Rhee & Haunschild, 2006) and the results were also sustained.

DISCUSSION

This study explores the effects of increased rates of change on product failure rates and quality reputation and provides also a new perspective on how firms learn from past product failures. The automotive industry was selected as context for the analysis given its increasingly technology-based status in terms of new products and manufacturing processes. The results indicate that when automakers increase change rates in model redesign, there is also an increase in recalls associated with assembly/design defects. Studies on product change have acknowledged that pressures to increase new product developments act against product quality (Bayus, 1997; Cooper, 2001; Lukas & Menon, 2004). Bayus (1997) highlights that managers believe that when product developments have to be developed in compressed time spans, quality is automatically hampered as this trade-off is represented by the statement: “Good, fast, cheap . . . Pick any two”. However, studies lack specificity on which aspects involved in the product manufacturing are more negatively impacted by such pressures. This study brings to light that in-house operations are more prone to incur in assembly/design defects when product changes are increased. That is also true when manufacturing processes are changed. The results show that when automakers change a manufacturing platform, subsequent models models that had gone through this change tend to have more assembly/design defects. These findings emphasize that in complex product industries such as automotive, firms managing new product developments find great difficulties in upgrading their products and processes without compromising final product quality. This confirms also automotive specialists recommendations to avoid newly launched models due to their increased defect rates (Newman, 2014).

Another new important perspective brought by this study is the observation of supplier changes on outsourced component failure rates. The results indicate that recalls involving a component defect are more common when a supplier has been switched. This finding suggests that firms looking for ways to reduce costs via outsourcing are able to benefit more from suppliers when the relationship is stable over time (Dyer & Nobeoka, 2000; Song & Di Benedetto, 2008). It also indicates that firms need even greater supplier involvement with new suppliers in order to mitigate product failure rates. Switching suppliers too often also increases monitoring and training costs, thus representing a poor strategy to be followed by firms developing complex products. In sum, I provide evidence that assembly-related and supplier-related product failures have different sources and also need to be approached using different strategies.

With regards to brand quality reputation, the results confirm the prediction that firms with increased model redesigns are able to raise their quality reputation assessments. It provides evidence that even though firms with more model redesigns incur in more recalls, that does not necessarily mean that their models are assessed as having lower quality. This is partly because voluntary and non-severe automotive recalls can be seen by customers as a signal that the automaker is aware and paying attention to the quality of the product. This perspective is provided by Haunschild and Rhee (2004) based on interviews with industry experts. The authors also highlight that non-severe recalls actually can increase firm sales while severe recalls diminish it. In fact, analysts have argued that "…it's unusual for a recall to negatively impact new vehicle sales and market share or used vehicle prices". Moreover, the most common problems encountered by customers in their quality assessments used in reliability indexes are related to issues such as wireless connectivity, navigation or tire pressure monitoring system, which are usually not reported on safety recalls. Yet, a recent study by national automobile dealers’ association (NADA) shows that while in the 80s the average vehicle age involved in a recall was around 24 months, in 2014 this age was raised to 50 months, and that vehicles had a 53% improvement in quality from 2000 to 2013. This indicates that newer models, such as redesigned ones, are very unlikely to have a negative quality assessment due to its recalls rates. Therefore, automakers who invest in more redesigns are capable of satisfying their customers’ needs as their new products are improved in quality over time.

Lastly, this study contributes to the organizational learning literature by reinforcing the idea that firms have different learning process regarding voluntary or involuntary corrective actions (Haunschild & Rhee, 2004). The results indicate that automakers are able to increase brand quality reputation from past experiences with voluntary recalls. Voluntary recalls are the result of internal investigations and research which show that the firm has internal routines that are conducive of learning and continuous improvement. On the other hand, results show that involuntary recalls have a negative effect on quality reputation. Involuntary recalls are the outcome of either NHTSA independent investigation or vehicle owners’ complaints. This means that involuntary recalls are caused by defects in which the automaker could not detect in its internal assessments, thus showing that the firm does not have means of detection and solution for that problem internalized. In this case, involuntary recalls are more likely to generate a defensive response where the automaker react by just complying with the necessary requirements (Kostova & Roth, 2002; Meyer & Rowan, 1977) which in turn results in shallower learning. Yet, the negative effect of involuntary recalls on quality reputation confirms automotive industry experts argument that involuntary recalls are negatively seen by both consumers and automakers (Haunschild & Rhee, 2004).

CONCLUSION

By analyzing the effects of product, process and supplier changes on product recalls and how automakers learn from these experiences, this study provides important contributions to the organizational learning literature. I highlight that in the context of increased pressures for change, firms have greater difficulties to upgrade their products and processes without incurring in greater failure rates. That goes against the common believe that newer products are always better as we can see that complex products such as automotive tend to have higher failure rates when newly redesigned. The finding that supplier changes are more likely to produce component failures also reinforce the notion that complex products need great levels of supplier integration and stable supply agreements. Yet, the effects on quality reputation caused by increased model redesigns confirm that firms with increased capacity to redesign their products are also able to raise overall product quality by learning how to improve their processes and at the same time to build up reputation with customers. I highlight that these learning effects are more pronounced when firms voluntarily and proactively search for errors in-house as opposed to when an external corrective mandate occurs. Therefore, I conclude that firms in the context of increased pressures for change need to focus on stable operations with suppliers and at the same reinforce their internal procedures of learning from errors in order to leverage their products quality and brand reputation. These findings are useful for managers in the sense that it informs that although product and processes changes are a necessary for sustainable competitive advantage, more attention needs to be drawn to learning not only from internal procedures but also from external mandates. Instead of fearing and avoiding bad feedbacks (Jackman & Strober, 2003), firms could greatly benefit from the learning acquired and retained from recalls identified outside of their plants. Managers also can be informed that supplier involvement brings not only more efficient, innovative and profitable operations but also reduces the risk of serious errors of production. Yet, the differences between assembly-related and supplier-related failures are important to be noted since they also require different strategies in order to be reduced.

Some limitations of this study should be highlighted. First, it is a single industry study, so the implications from the presented findings should be more closely related to complex product industries such as computer and mobile phone. It also utilizes product recalls as a proxy of product failure, however not all product failures are encompassed in automotive safety recalls so the focus in this study is on the most relevant and serious defects. The measurement of brand quality is also based solely on customers’ assessments of product defect rates but other measures of quality such as environmentally clean, social responsibility and institutional ownership may also play a role. A promising avenue for future studies is to assess how product and process change rates are improved over time as firms learn how to better manufacture their products. Possible mediators are also important to be noted such as modular production methods, outsourcing degree and use of more advanced technologies.

References

Abernathy, W. J. (1976). The Productivity Dilemma; Roadblock to Innovation in the Automobile Industry.

Acha, V., Davies, A., Hobday, M., & Salter, A. (2004). Exploring the capital goods economy: complex product systems in the UK. *Industrial and Corporate Change*, *13*(3), 505–529. http://doi.org/10.1093/icc/dth020

Adner, R., & Kapoor, R. (2010). Value creation in innovation ecosystems: how the structure of technological interdependence affects firm performance in new technology generations. *Strategic Management Journal*, *31*(3), 306–333. http://doi.org/10.1002/smj.821

Afuah, A. (2001). Dynamic Boundaries of the Firm: Are Firms Better Off Being Vertically Integrated in the Face of a Technological Change? *Academy of Management Journal*, *44*(6), 1211–1228. http://doi.org/10.2307/3069397

Ahuja, G. (2000). Collaboration Networks, Structural Holes, and Innovation: A Longitudinal Study. *Administrative Science Quarterly*, *45*(3), 425. http://doi.org/10.2307/2667105

Ahuja, G., & Katila, R. (2001). Technological acquisitions and the innovation performance of acquiring firms: a longitudinal study. *Strategic Management Journal*, *22*(3), 197–220. http://doi.org/10.1002/smj.157

Andrevski, G., Brass, D. J., & Ferrier, W. J. (2013). Alliance Portfolio Configurations and Competitive Action Frequency. *Journal of Management*, (August 2013). http://doi.org/10.1177/0149206313498901

Aoshima, Y. (2002). Transfer of System Knowledge Across Generations in New Product Development: Empirical Observations from Japanese Automobile Development. *Industrial Relations*, *41*(4), 605–628. http://doi.org/10.1111/1468-232X.00266

Argyres, N. (1996). Evidence on the role of firm capabilities in vertical integration decisions. *Strategic Management Journal*.

Argyres, N. S., & Zenger, T. R. (2012). Capabilities, Transaction Costs, and Firm Boundaries. *Organization Science*, *23*(6), 1643–1657. http://doi.org/10.1287/orsc.1110.0736

Argyres, N., & Bigelow, L. (2010). Innovation, Modularity, and Vertical Deintegration: Evidence from the Early U.S. Auto Industry. *Organization Science*, *21*(4), 842–853. http://doi.org/10.1287/orsc.1090.0493

Bain, J. S. (1956). Barriers to new competition: their character and consequences in manufacturing industries, *329*.

Baldwin, C. Y. (2014). Bottlenecks, Modules and Dynamic Architectural Capabilities. Working Paper (Harvard Business School).

Baldwin, C. Y., & Clark, K. B. (2000). Design Rules: The Power of Modularity, *1*, 471.

Banbury, C. M., & Mitchell, W. (1995). The effect of introducing important incremental innovations on market share and business survival. *Strategic Management Journal, 16*(S1), 161–182. http://doi.org/10.1002/smj.4250160922

Banker, R. D., Datar, S. M., Kekre, S., & Mukhopadhyay, T. (1990). Costs of product and process complexity. In *Measures of Manufacturing Excellenc* (Vol. 2, pp. 269–290). Harvard Business School Press, Boston, MA.

Barney, J. B. (1996). The Resource-Based Theory of the Firm. *Organization Science, 7*(5), 469–469. http://doi.org/10.1287/orsc.7.5.469

Bayus, B. L. (1997). Speed-to-Market and New Product Performance Trade-offs. *Journal of Product Innovation Management*, *14*(6), 485–497. http://doi.org/10.1111/1540-5885.1460485

Ben-Shahar, O., & White, J. J. (2006). Boilerplate and economic power in auto manufacturing contracts. *Michigan Law Review*.

Benner, M. J., & Tushman, M. L. (2003). Exploitation, Exploration, and Process Management: The Productivity Dilemma Revisited. *The Academy of Management Review*, *28*(2), 238. http://doi.org/10.2307/30040711

Bettis, R. A., Bradley, S. P., & Hamel, G. (1992). Outsourcing and industrial decline. *The Academy of Management Executive*, *6*(1), 7–22. http://doi.org/10.5465/AME.1992.4274298

Blackburn, J. D. (1991). Time-based competition: the next battleground in American manufacturing.

Blau, P. M. (1964). Exchange and power in social life.

Blonigen, B. A., Knittel, C. R., & Soderbery, A. (2013). Keeping it Fresh: Strategic Product Redesigns and Welfare. National Bureau of Economic Research.

Blumberg, M., & Gerwin, D. (1984). Coping with advanced manufacturing technology. *Journal of Organizational Behavior, 5*(2), 113–130. http://doi.org/10.1002/job.4030050204

Bomey, N. (2016, January 21). U.S. auto recalls hit all-time record in 2015. Retrieved January 21, 2016, from

Borgatti, S. P., Everett, M. G., & Freeman, L. C. (2002). Ucinet for Windows: Software for social network analysis.

Bowman, C., & Ambrosini, V. (2000). Value creation versus value capture: towards a coherent definition of value in strategy. *British Journal of Management*, *11*(1), 1–15.

Bradshaw, T. (2015, May 25). Apple eyes the car as “ultimate mobile device.” Retrieved February 28, 2016, from

Brandenburger, A. M., & Stuart, H. W. (1996). Value-based business strategy. *… And Management Strategy*.

Brusoni, S., Jacobides, M. G., & Prencipe, A. (2009). Strategic dynamics in industry architectures and the challenges of knowledge integration. *European Management Review*, *6*(4), 209–216. http://doi.org/10.1057/emr.2009.26

Bulow, J. (1986). An Economic Theory of Planned Obsolescence. *The Quarterly Journal of Economics*, *101*(4), 729.

Burt, R. S. (1992). Structural Holes: The Social Structure of Competition, 324. Retrieved from http://books.google.com/books?hl=en&lr=&id=FAhiz9FWDzMC&pgis=1

Carrillo, J. E., & Gaimon, C. (2000). Improving Manufacturing Performance Through Process Change and Knowledge Creation. *Management Science*, *46*(2), 265–288. http://doi.org/10.1287/mnsc.46.2.265.11925

Chao, G. H., Iravani, S. M. R., & Savaskan, R. C. (2009). Quality Improvement Incentives and Product Recall Cost Sharing Contracts. *Management Science*, *55*(7), 1122–1138. http://doi.org/10.1287/mnsc.1090.1008

Chatterjee, S. (1991). Gains In Vertical Acquisitions and Market Power: Theory and Evidence. *Academy of Management Journal*, *34*(2), 436–448. http://doi.org/10.2307/256450

Chen, S.-F. S. (2005). Extending internalization theory: a new perspective on international technology transfer and its generalization. *Journal of International Business Studies*, *36*(2), 231–245. http://doi.org/10.1057/palgrave.jibs.8400124

Christensen, C. M., & Overdorf, M. (2000). Meeting the challenge of disruptive change. *Harvard Business Review*.

Christensen, C. M., Verlinden, M., & Westerman, G. (2002). Disruption, disintegration and the dissipation of differentiability. *Industrial and Corporate Change*, *11*(5), 955–993. http://doi.org/10.1093/icc/11.5.955

Chuang, Y.-T., & Baum, J. A. C. (2003). It's All in the Name: Failure-Induced Learning by Multiunit Chains. *Administrative Science Quarterly*, *48*(1), 33–59.

http://doi.org/10.2307/3556618

Ciravegna, L., & Maielli, G. (2011). Outsourcing of new product development and the opening of innovation in mature industries: a longitudinal study of fiat during crisis and recovery

. *International Journal of Innovation Management*, *15*(01), 69–93. http://doi.org/10.1142/S1363919611003088

Clark, K. B. (1985). The interaction of design hierarchies and market concepts in technological evolution. *Research Policy*, *14*(5), 235–251. http://doi.org/10.1016/0048-7333(85)90007-1

Clark, K. B., & Fujimoto, T. (1991). Product Development Performance. Harvard Business Press.

Clausen, T., Pohjola, M., Sapprasert, K., Verspagen, B., & Verspagen, B. (2012). Innovation strategies as a source of persistent innovation. *Industrial and Corporate Change*, *21*(3), 553–585. http://doi.org/10.1093/icc/dtr051

Coase, R. H. (1937). The Nature of the Firm. *Economica*, *4*(16), 386–405. http://doi.org/10.2307/2626876

Coase, R. H. (2000). Acquisition of Fisher Body by General Motors, The. *JL & Econ*.

Cohen, W., & Levin, R. C. (1989). Empirical studies of innovation and market structure. *Handbook of Industrial Organization*.

Colias, M. (2015, June 22). **GM gambles on quick car redesigns in shifting market**. Retrieved December 20, 2015, from

Cooper, R. G. (2001). Winning at new products: accelerating the process from idea to launch. Cambridge.

D'Aveni, R. A., Dagnino, G. B., & Smith, K. G. (2010). The age of temporary advantage. *Strategic Management Journal*, *31*(13), 1371–1385. http://doi.org/10.1002/smj.897

Datar, S. M., Kekre, S., Srinivasan, K., & Mukhopadhyay, T. (1990). Simultaneous Cost of Engineering and Management of Complexity.

Davidson, W. N., & Worrell, D. L. (1992). Research notes and communications: The effect of product recall announcements on shareholder wealth. *Strategic Management Journal*, *13*(6), 467–473. http://doi.org/10.1002/smj.4250130606

Debruyne, M., Moenaertb, R., Griffinc, A., Hartd, S., Hultinke, E. J., & Robben, H. (2002). The impact of new product launch strategies on competitive reaction in industrial markets. *Journal of Product Innovation Management*, *19*(2), 159–170.

http://doi.org/10.1111/1540-5885.1920159

Dess, G. G., Rasheed, A. M. A., McLaughlin, K. J., & Priem, R. L. (1995). The new corporate architecture. *The Academy of Management Executive*, *9*(3), 7–18. http://doi.org/10.5465/AME.1995.9509210261

Devaraj, S., Matta, K. F., & Conlon, E. (2001). PRODUCT AND SERVICE QUALITY: THE ANTECEDENTS OF CUSTOMER LOYALTY IN THE AUTOMOTIVE INDUSTRY. *Production and Operations Management*, *10*(4), 424–439. http://doi.org/10.1111/j.1937-5956.2001.tb00085.x

Dobrev, S. D., Kim, T.-Y., & Carroll, G. R. (2002). The Evolution of Organizational Niches: U.S. Automobile Manufacturers, 1885–1981. *Administrative Science Quarterly*, *47*(2), 233–264. http://doi.org/10.2307/3094805

Duysters, G., de Man, A.-P., & Wildeman, L. (1999). A network approach to alliance management. *European Management Journal*, *17*(2), 182–187. http://doi.org/10.1016/S0263-2373(98)00077-2

Dyer, J. H. (1996). Specialized supplier networks as a source of competitive advantage: Evidence from the auto industry. *Strategic Management Journal*.

Dyer, J. H., & Hatch, N. W. (2006). Relation-specific capabilities and barriers to knowledge transfers: creating advantage through network relationships. *Strategic Management Journal*, *27*(8), 701–719. http://doi.org/10.1002/smj.543

Dyer, J. H., & Nobeoka, K. (2000). Creating and managing a high-performance knowledge-sharing network: the Toyota case. *Strategic Management Journal*, *21*(3), 345–367. http://doi.org/10.1002/(SICI)1097-0266(200003)21:3<345::AID-SMJ96>3.0.CO;2-N

Eisenhardt, K. M., & Martin, J. A. (2000). Dynamic capabilities: what are they? *Strategic Management Journal*, *21*(10-11), 1105–1121. http://doi.org/10.1002/1097-0266(200010/11)21:10/11<1105::AID-SMJ133>3.0.CO;2-E

Eppinger, S. D., Whitney, D. E., Smith, R. P., & Gebala, D. A. (1994). A model-based method for organizing tasks in product development. *Research in Engineering Design*, *6*(1), 1–13. http://doi.org/10.1007/BF01588087

Esteban, S., & Shum, M. (2007). Durable-goods oligopoly with secondary markets: the case of automobiles. *The RAND Journal of Economics*, *38*(2), 332–354. http://doi.org/10.1111/j.1756-2171.2007.tb00071.x

Ethiraj, S. K., & Levinthal, D. (2004). Modularity and Innovation in Complex Systems. *Management Science*, *50*(2), 159–173. http://doi.org/10.1287/mnsc.1030.0145

Ethiraj, S. K., Levinthal, D., & Roy, R. R. (2008). The Dual Role of Modularity:

Innovation and Imitation. *Management Science*, *54*(5), 939–955. http://doi.org/10.1287/mnsc.1070.0775

Fidler, L. A., & Johnson, J. D. (1984). Communication and Innovation Implementation. *Academy of Management Review*, *9*(4), 704–711. http://doi.org/10.5465/AMR.1984.4277422

Fine, C. H. (1998). Clockspeed: Winning industry control in the age of temporary advantage. Cambridge: Perseus.

Fombrun, C., & Shanley, M. (1990). What's in a Name? Reputation Building and Corporate Strategy. *Academy of Management Journal*, *33*(2), 233–258. http://doi.org/10.2307/256324

Fourcade, F., & Midler, C. (2005). The role of 1st tier suppliers in automobile product modularisation: the search for a coherent strategy. *International Journal of Automotive Technology and Management*. http://doi.org/10.1504/ijatm.2005.5.issue-2;pageGroup:string:Publication

Fresard, L., Hoberg, G., & Phillips, G. (2013a). The incentives for vertical mergers and vertical integration. *Research Policy*, *2*, 452–466.

Fresard, L., Hoberg, G., & Phillips, G. (2013b). The incentives for vertical mergers and vertical integration. *Research Policy*.

Fujimoto, T., & Clark, K. B. (1991). Product Development Performance: Strategy, Organization, and Management in the World Auto Industry.

Furlan, A., Cabigiosu, A., & Camuffo, A. (2014). When the mirror gets misted up: Modularity and technological change. *Strategic Management Journal*, *35*(6), 789–807. http://doi.org/10.1002/smj.2138

Gardiner, J. C., Luo, Z., & Roman, L. A. (2009). Fixed effects, random effects and GEE: What are the differences? *Statistics in Medicine*, *28*(2), 221–239. http://doi.org/10.1002/sim.3478

Garvin, D. A. (1983). Quality on the line. Harvard business review. http://doi.org/10.1111/j.1540-5915.1989.tb01421.x/abstract

Gautam, N., & Singh, N. (2008). Lean product development: Maximizing the customer perceived value through design change (redesign). *International Journal of Production Economics*, *114*(1), 313–332.

Gereffi, G., Sturgeon, T., & Humphrey, J. (2005). The governance of global value chains. *Review of International Political Economy*, *12*(1), 78–104. http://doi.org/10.1080/09692290500049805

Gilley, K. M., & Rasheed, A. (2000). Making More by Doing Less: An Analysis of Outsourcing and its Effects on Firm Performance. *Journal of Management*, *26*(4), 763–790. http://doi.org/10.1177/014920630002600408

Grafton, S. M., Hoffer, G. E., & Reilly, R. J. (1981). TESTING THE IMPACT OF RECALLS ON THE DEMAND FOR AUTOMOBILES. *Economic Inquiry*, *19*(4), 694–703. http://doi.org/10.1111/j.1465-7295.1981.tb00348.x

Guimaraes, T., Cook, D., & Natarajan, N. (2002). Exploring the Importance of Business Clockspeed as a Moderator for Determinants of Supplier Network Performance. *Decision Sciences*, *33*(4), 629–644. http://doi.org/10.1111/j.1540-5915.2002.tb01659.x

Gujarati, D. N. (1995). Basic econometrics, 3rd. Mc Graw-Hills Int eds.

Guth, W. D., & Macmillan, I. C. (1986). Strategy implementation versus middle management self-interest. *Strategic Management Journal*, *7*(4), 313–327. http://doi.org/10.1002/smj.4250070403

Hadjinicola, G. C., & Kumar, K. R. (2005). Product Redesign and Pricing in Response to Competitor Entry: A Marketing-Production Perspective. In C. T. Leondes (Ed.), *Intelligent Knowledge-Based Systems* (pp. 708–730). Boston, MA: Springer US. http://doi.org/10.1007/978-1-4020-7829-3_20

Handfield, R. B., Petersen, K. J., Petersen, K. J., Handfield, R. B., & Ragatz, G. L. (2005). Supplier integration into new product development: coordinating product, process and supply chain design. *Journal of Operations Management*, *23*(3-4), 371–388. http://doi.org/10.1016/j.jom.2004.07.009

Harrigan, K. R. (1984a). Formulating Vertical Integration Strategies. *Academy of Management Review*, *9*(4), 638–652. http://doi.org/10.5465/AMR.1984.4277387

Harrigan, K. R. (1984b). Formulating Vertical Integration Strategies. *The Academy of Management Review*, *9*(4), 638. http://doi.org/10.2307/258487

Haunschild, P. R., & Rhee, M. (2004). The Role of Volition in Organizational Learning: The Case of Automotive Product Recalls. *Management Science*, *50*(11), 1545–1560. http://doi.org/10.1287/mnsc.1040.0219

Haunschild, P. R., & Sullivan, B. N. (2002). Learning from Complexity: Effects of Prior Accidents and Incidents on Airlines' Learning. *Administrative Science Quarterly*, *47*(4), 609–643. http://doi.org/10.2307/3094911

Haunschild, P. R., Polidoro, F., Jr, & Chandler, D. (2015). Organizational Oscillation Between Learning and Forgetting: The Dual Role of Serious Errors. *Organization Science*, *26*(6), 1682–1701. http://doi.org/10.1287/orsc.2015.1010

Hedge, M. (2015, May 19). Poor Supplier Relations Costing U.S. Automakers Millions. Retrieved November 5, 2015, from

Helfat, C. E., & Raubitschek, R. S. (2000). Product sequencing: co-evolution of knowledge, capabilities and products. *Strategic Management Journal*.

Helper, S. (1991). How much has really changed between US automakers and their suppliers? *MIT Sloan Management Review*.

Henderson, R. M., & Clark, K. B. (1990). Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms. *Administrative Science Quarterly*, *35*(1), 9. http://doi.org/10.2307/2393549

Hidalgo, C. A., Klinger, B., Barabási, A. L., & Hausmann, R. (2007). The Product Space Conditions the Development of Nations. *Science*, *317*(5837), 482–487. http://doi.org/10.1126/science.1144581

Hitt, M. A., Hoskisson, R. E., Johnson, R. A., & Moesel, D. D. (1996). The Market for Corporate Control and Firm Innovation. *Academy of Management Journal*, *39*(5), 1084–1119. http://doi.org/10.2307/256993

Hobday, M. (1998). Product complexity, innovation and industrial organisation. *Research Policy*, *26*(6), 689–710. http://doi.org/10.1016/S0048-7333(97)00044-9

Hoberg, G., & Phillips, G. (2010). Product Market Synergies and Competition in Mergers and Acquisitions: A Text-Based Analysis. *Review of Financial Studies*, *23*(10), 3773–3811. http://doi.org/10.1093/rfs/hhq053

Hoetker, G. (2004). How much you know versus how well I know you: selecting a supplier for a technically innovative component. *Strategic Management Journal*, *26*(1), 75–96. http://doi.org/10.1002/smj.453

Hoffmann, W. H. (2007). Strategies for managing a portfolio of alliances. *Strategic Management Journal*, *28*(8), 827–856. http://doi.org/10.1002/smj.607

Hora, M., Bapuji, H., & Roth, A. V. (2011). Safety hazard and time to recall: The role of recall strategy, product defect type, and supply chain player in the U.S. toy industry. *Journal of Operations Management*, *29*(7-8), 766–777.

Hult, G. T. M., Ketchen, D. J., & Arrfelt, M. (2007). Strategic supply chain management: Improving performance through a culture of competitiveness and knowledge development. *Strategic Management Journal*, *28*(10), 1035–1052. http://doi.org/10.1002/smj.627

Jackman, J. M., & Strober, M. H. (2003). Fear of feedback. *Harvard Business Review*.

Jacobides, M. G., & Billinger, S. (2006). Designing the Boundaries of the Firm: From

“Make, Buy, or Ally” to the Dynamic Benefits of Vertical Architecture. *Organization Science*, *17*(2), 249–261. http://doi.org/10.1287/orsc.1050.0167

Jacobides, M. G., & Winter, S. G. (2005). The co-evolution of capabilities and transaction costs: explaining the institutional structure of production. *Strategic Management Journal*, *26*(5), 395–413. http://doi.org/10.1002/smj.460

Jacobides, M. G., & Winter, S. G. (2012). Capabilities: Structure, Agency, and Evolution. *Organization Science*, *23*(5), 1365–1381. http://doi.org/10.1287/orsc.1110.0716

Jacobides, M. G., Knudsen, T., & Augier, M. (2006). Benefiting from innovation: Value creation, value appropriation and the role of industry architectures. *Research Policy*, *35*(8), 1200–1221. http://doi.org/10.1016/j.respol.2006.09.005

Jacobides, M. G., MacDuffie, J. P., & Tae, C. J. (2012). When value sticks around : Why automobile OEMs still rule their sector. *Industry Studies Association Conference*, 1–65.

Jacobides, M. G., MacDuffie, J. P., & Tae, C. J. (2015). Agency, structure, and the dominance of OEMs: Change and stability in the automotive sector. *Strategic Management Journal*, n/a–n/a. http://doi.org/10.1002/smj.2426

Kalaignanam, Kushwaha, T., & Eilert, M. (2013). The Impact of Product Recalls on Future Product Reliability and Future Accidents: Evidence from the Automobile Industry. *Dx.Doi.org*, *77*(2), 41–57. http://doi.org/10.1509/jm.11.0356

Kaldor, N. (1967). Strategic factors in economic development. Ithaca, NY: New York State School of Industrial and Labor Relations.

Kamrani, A. K., & Sa'ed, M. S. (2002). Product design for modularity.

Kang, M.-P., Mahoney, J. T., & Tan, D. (2009). Why firms make unilateral investments specific to other firms: the case of OEM suppliers. *Strategic Management Journal*, *30*(2), 117–135. http://doi.org/10.1002/smj.730

Kapoor, R., & Adner, R. (2012). What Firms Make vs. What They Know: How Firms' Production and Knowledge Boundaries Affect Competitive Advantage in the Face of Technological Change. *Organization Science*, *23*(5), 1227–1248. http://doi.org/10.1287/orsc.1110.0686

Kapoor, R., & Lim, K. (2007). The impact of acquisitions on the productivity of inventors at semiconductor firms: a synthesis of knowledge-based and incentive-based perspectives.

. *Academy of Management Journal*, *50*(5), 1133–1155. http://doi.org/10.5465/AMJ.2007.27169706

Katila, R., & Ahuja, G. (2002). Something Old, Something New: A Longitudinal Study of Search Behavior and New Product Introduction. *Academy of Management Journal*, *45*(6), 1183–1194. http://doi.org/10.2307/3069433

Kessler, E. H., & Chakrabarti, A. K. (1996). Innovation Speed: A Conceptual Model of Context, Antecedents, and Outcomes. *The Academy of Management Review*, *21*(4), 1143. http://doi.org/10.2307/259167

Klayman, B., & Lienert, P. (2014, October 3). GM's bold platform plan aims to reduce complexity, save billions

. Retrieved October 3, 2014, from

Klein, B., Crawford, R. G., & Alchian, A. A. (1978). Vertical integration, appropriable rents, and the competitive contracting process. *Journal of Law and Economics*. http://doi.org/10.2307/725234

Kline, S. J. (1990). A numerical measure for the complexity of systems: the concept and some implications. *Report INN-5, Dept. of Mechanical Engineering, Stanford University*.

Knittel, C. R. (2009). Automobiles on steroids: Product attribute trade-offs and technological progress in the automobile sector.

Kogut, B. (2013). The Stability of Joint Ventures : Reciprocity and Competitive Rivalry Author (s): Bruce Kogut Published by : Wiley THE STABILITY OF JOINT VENTURES : RECIPROCITY AND COMPETITIVE RIVALRY *, *38*(2), 183–198.

Kogut, B., & Zander, U. (1992). Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology. *Organization Science*, *3*(3), 383–397. http://doi.org/10.1287/orsc.3.3.383

Kostova, T., & Roth, K. (2002). Adoption of an Organizational Practice by Subsidiaries of Multinational Corporations: Institutional and Relational Effects. *Academy of Management Journal*, *45*(1), 215–233. http://doi.org/10.2307/3069293

Kotabe, M., Parente, R., & Murray, J. Y. (2007). Antecedents and outcomes of modular production in the Brazilian automobile industry: a grounded theory approach. *Journal of International Business Studies*, *38*(1), 84–106. http://doi.org/10.1057/palgrave.jibs.8400244

Koufteros, X. A., Edwin Cheng, T. C., & Lai, K.-H. (2007). “Black-box” and ‘gray-box’ supplier integration in product development: Antecedents, consequences and the moderating role of firm size. *Journal of Operations Management*, *25*(4), 847–870.

Koufteros, X. A., Vonderembse, M. A., & Doll, W. J. (2002). Integrated product development practices and competitive capabilities: the effects of uncertainty, equivocality, and platform strategy. *Journal of Operations Management, 20*(4), 331–355.

Lahiri, N. (2010). Geographic Distribution of R&D Activity: How Does it Affect Innovation Quality? *Academy of Management Journal*, *53*(5), 1194–1209. http://doi.org/10.5465/AMJ.2010.54533233

Lahiri, N., & Narayanan, S. (2013). Vertical integration, innovation, and alliance portfolio size: Implications for firm performance. *Strategic Management Journal*, *34*(9), 1042–1064. http://doi.org/10.1002/smj.2045

Lakshman, C., & Parente, R. C. (2007). Supplier-Focused Knowledge Management in the Automobile Industry and Its Implications for Product Performance. *Journal of Management Studies*, *0*(0), 071107180807001–??? http://doi.org/10.1111/j.1467-6486.2007.00743.x

Langlois, R. N. (1992). Transaction-cost Economics in Real Time. *Industrial and Corporate Change*, *1*(1), 99–127. http://doi.org/10.1093/icc/1.1.99

Langlois, R. N., & Robertson, P. L. (1992). Networks and innovation in a modular system: Lessons from the microcomputer and stereo component industries. *Research Policy*, *21*(4), 297–313. http://doi.org/10.1016/0048-7333(92)90030-8

Langlois, R. N., & Robertson, P. L. (2002). Firms, markets and economic change: A dynamic theory of business institutions. Routledge. Retrieved from https://books.google.com/books?hl=pt-BR&lr=&id=iPeHAgAAQBAJ&pgis=1

Lave, C. A., & March, J. G. (1993). An introduction to models in the social sciences.

Lavie, D. (2007). Alliance Portfolios and Firm Performance: A Study of Value Creation and Appropriation in the U.S. Software Industry.

Lavie, D., & Rosenkopf, L. (2006). Balancing exploration and exploitation in alliance formation.

. *Academy of Management Journal*, *49*(4), 797–818. http://doi.org/10.5465/AMJ.2006.22083085

Lavie, D., Kang, J., & Rosenkopf, L. (2011). Balance Within and Across Domains: The Performance Implications of Exploration and Exploitation in Alliances. *Organization Science*, *22*(6), 1517–1538. http://doi.org/10.1287/orsc.1100.0596

Lazzarini, S. G., Claro, D. P., & Mesquita, L. F. (2008). Buyer–Supplier and Supplier–Supplier Alliances: Do They Reinforce or Undermine One Another? *Journal of Management Studies*, *45*(3), 561–584. http://doi.org/10.1111/j.1467-6486.2007.00748.x

Lehnerd, A. P., & Meyer, M. H. (2011). The Power of Product Platforms. Simon and Schuster.

Levin. (2000). Organizational Learning and the Transfer of Knowledge: An Investigation of Quality Improvement. *Organization Science*, *11*(6), 630–647. http://doi.org/10.1287/orsc.11.6.630.12535

Levin, D. (2015, October 26). Auto recalls are spiking - here's why. Retrieved February 29, 2016, from

Levinthal, D. A., & March, J. G. (1993). The myopia of learning. *Strategic Management Journal*, *14*(S2), 95–112. http://doi.org/10.1002/smj.4250141009

Levitt, B., & March, J. G. (1988). Organizational learning. *Annual Review of Sociology*.

Levy, D. L. (1997). Lean production in an international supply chain. *MIT Sloan Management Review*.

Liang, K.-Y., & Zeger, S. L. (1986). Longitudinal Data Analysis Using Generalized Linear Models. *Biometrika*, *73*(1), 13. http://doi.org/10.2307/2336267

Lieberman, M. B., & Montgomery, D. B. (1988). First-mover advantages. *Strategic Management Journal*, *9*(S1), 41–58. http://doi.org/10.1002/smj.4250090706

Lippman, S. A., & Rumelt, R. P. (1982). Uncertain Imitability: An Analysis of Interfirm Differences in Efficiency under Competition. *The Bell Journal of Economics*, *13*(2), 418. http://doi.org/10.2307/3003464

Lmai, M. (1986). Kaizen : the Key to Japan's Competitive Success. New York: Random House.

Lukas, B. A., & Menon, A. (2004). New product quality: intended and unintended consequences of new product development speed. *Journal of Business Research*, *57*(11), 1258–1264.

MacDuffie, J. P. (1995). Human Resource Bundles and Manufacturing Performance: Organizational Logic and Flexible Production Systems in the World Auto Industry. *Industrial & Labor Relations Review*, *48*(2), 197–221. http://doi.org/10.1177/001979399504800201

MacDuffie, J. P. (2013). Modularity-as-Property, Modularization-as-Process, and ‘Modularity'-as-Frame: Lessons from Product Architecture Initiatives in the Global Automotive Industry. *Global Strategy Journal*, *3*(1), 8–40. http://doi.org/10.1111/j.2042-5805.2012.01048.x

MacDuffie, J. P., & Fujimoto, T. (2010). Why dinosaurs will keep ruling the auto industry. Harvard Business Review.

MacDuffie, J. P., & Helper, S. (1997). Creating Lean Suppliers: Diffusing Lean Production Through the Supply Chain, *39*(4), 118–151.

MacDuffie, J. P., Sethuraman, K., & Fisher, M. L. (1996). Product variety and manufacturing performance: evidence from the international automotive assembly plant study. *Management Science*, *42*(3), 350–369.

Mahoney, J. T. (1992). The choice of organizational form: vertical financial ownership versus other methods of vertical integration. *Strategic Management Journal*.

Malerba, F., & Orsenigo, L. (1996). The Dynamics and Evolution of Industries. *Industrial and Corporate Change*, *5*(1), 51–87. http://doi.org/10.1093/icc/5.1.51

March, J. G. (1991). Exploration and Exploitation in Organizational Learning., *2*(1), 71–87.

Marcus, A. A. (1988). Implementing Externally Induced Innovations: A Comparison of Rule-Bound and Autonomous Approaches. *Academy of Management Journal*, *31*(2), 235–256. http://doi.org/10.2307/256547

Marcus, A. A., & Nichols, M. L. (1999). On the Edge: Heeding the Warnings of Unusual Events. *Organization Science*, *10*(4), 482–499. http://doi.org/10.1287/orsc.10.4.482

McNally, R. C., Akdeniz, M. B., & Calantone, R. J. (2011). New Product Development Processes and New Product Profitability: Exploring the Mediating Role of Speed to Market and Product Quality. *Journal of Product Innovation Management*, *28*(s1), 63–77. http://doi.org/10.1111/j.1540-5885.2011.00861.x

Mendelson, H., & Pillai, R. (1999). Industry Clockspeed: Measurement and Operational Implications. *Manufacturing & Service Operations Management*, *1*(1), 1–20. http://doi.org/10.1287/msom.1.1.1

Menon, A., Chowdhury, J., & Lukas, B. A. (2002). Antecedents and outcomes of new product development speed. *Industrial Marketing Management*, *31*(4), 317–328. http://doi.org/10.1016/S0019-8501(01)00163-8

Meyer, & Rowan, B. (1977). Institutionalized Organizations: Formal Structure as Myth and Ceremony. *American Journal of Sociology*, *83*(2), 340. http://doi.org/10.1086/226550

Mike, D., Mats, W., Javier, F., & Oriol, J. (2007). Platform thinking in the automotive industry–managing the dualism between standardization of components for large scale production and variation for market …. *Product Innovation and …*.

Milgrom, P., & Roberts, J. (1982). Predation, reputation, and entry deterrence. *Journal of Economic Theory*, *27*(2), 280–312. http://doi.org/10.1016/0022-0531(82)90031-X

Monteverde, K., & Teece, D. J. (1982). Supplier Switching Costs and Vertical Integration in the Automobile Industry. *The Bell Journal of Economics*, *13*(1), 206–213. http://doi.org/10.2307/3003441

Nadkarni, S., & Narayanan, V. K. (2007). Strategic schemas, strategic flexibility, and firm performance: the moderating role of industry clockspeed. *Strategic Management Journal*, *28*(3), 243–270. http://doi.org/10.1002/smj.576

Newman, R. (2014, April 23). Buying a car? You may want to avoid the newest models. Retrieved March 4, 2016, from

Nickerson, J. A., & Zenger, T. R. (2004). A Knowledge-Based Theory of the Firm—The Problem-Solving Perspective. *Organization Science*, *15*(6), 617–632. http://doi.org/10.1287/orsc.1040.0093

Nieuwenhuis, P., & Wells, P. (2015). The Global Automotive Industry.

Novak, S., & Eppinger, S. D. (2001). Sourcing By Design: Product Complexity and the Supply Chain. *Management Science*, *47*(1), 189–204. http://doi.org/10.1287/mnsc.47.1.189.10662

Novak, S., & Stern, S. (2008). How Does Outsourcing Affect Performance Dynamics? Evidence from the Automobile Industry. *Management Science*, *54*(12), 1963–1979. http://doi.org/10.1287/mnsc.1080.0922

O'Grady, P. J. (1999). The age of modularity. Adams & Steele.

Orsenigo, L., & Sterzi, V. (2010). Comparative Study of the use of patents in different industries. *Bocconi University (KITes Working Paper 33/2010).*

Parente, R. C., & Geleilate, J. M. G. (2015). Developing new products in the automotive industry: exploring the interplay between process clockspeed and supply chain integration. *Industrial and Corporate Change*, dtv039.

Parkhe, A., Wasserman, S., & Ralston, D. A. (2006). New Frontiers in Network Theory Development. *Academy of Management Review*, *31*(3), 560–568. http://doi.org/10.5465/AMR.2006.21318917

Pavitt, K. (1988). Uses and abuses of patent statistics.

Pawels, K., Srinivasan, S., Silva-Risso, J., & Hanssen, D. M. (2003). New Products, Sales Promotions and Firm Value, with App lication to the Automobile Industry. Journal of Marketing.

Perona, M., & Miragliotta, G. (2004). Complexity management and supply chain performance assessment. A field study and a conceptual framework. *International Journal of Production Economics*, *90*(1), 103–115.

Peteraf, M. A. (1993). The cornerstones of competitive advantage: A resource-based view. *Strategic Management Journal*, *14*(3), 179–191. http://doi.org/10.1002/smj.4250140303

Petersen, K. J., Handfield, R. B., & Ragatz, G. L. (2005). Supplier integration into new product development: coordinating product, process and supply chain design. *Journal of Operations Management*, *23*(3-4), 371–388.

Phelps, C. C. (2010). A Longitudinal Study of the Influence of Alliance Network Structure and Composition on Firm Exploratory Innovation. *Academy of Management Journal*, *53*(4), 890–913. http://doi.org/10.5465/AMJ.2010.52814627

Pil, F. K., & Cohen, S. K. (2006). Modularity: Implications for Imitation, Innovation, and Sustained Advantage. *Academy of Management Review*, *31*(4), 995–1011. http://doi.org/10.5465/AMR.2006.22528166

Podolny, J. M., & Phillips, D. J. (1996). The Dynamics of Organizational Status. *Industrial and Corporate Change*, *5*(2), 453–471. http://doi.org/10.1093/icc/5.2.453

Polidoro, F., Ahuja, G., & Mitchell, W. (2011). When the Social Structure Overshadows Competitive Incentives: The Effects of Network Embeddedness on Joint Venture Dissolution. *Academy of Management Journal*, *54*, 203–223. http://doi.org/10.5465/AMJ.2011.59215088

Porter, M. E. (1980). Competitive strategy: Techniques for analyzing industries and competition. *New York*, 300.

Porter, M. E. (1981). The Contributions of Industrial Organization To Strategic Management. *Academy of Management Review*, *6*(4), 609–620. http://doi.org/10.5465/AMR.1981.4285706

Rao, H. (1994). The Social Construction of Reputation: Certification Contests, Legitimation, and the Survival of Organizations in the American Automobile Industry: 1895–1912. *Strategic Management Journal*, *15*(S1), 29–44. http://doi.org/10.1002/smj.4250150904

Reuters, T. (2016, January 7). The 2016 State of Self-Driving Automotive Innovation. Retrieved March 5, 2016, from

Rhee, M., & Haunschild, P. R. (2006). The Liability of Good Reputation: A Study of Product Recalls in the U.S. Automobile Industry. *Organization Science*, *17*(1), 101–117. http://doi.org/10.1287/orsc.1050.0175

Rindova, V. P., Williamson, I. O., Petkova, A. P., & Sever, J. M. (2005). Being Good or Being Known: An Empirical Examination of the Dimensions, Antecedents, and Consequences of Organizational Reputation. *Academy of Management Journal*, *48*(6), 1033–1049. http://doi.org/10.5465/AMJ.2005.19573108

Rivkin, J. W. (2000). Imitation of Complex Strategies. *Management Science*, *46*(6), 824–844. http://doi.org/10.1287/mnsc.46.6.824.11940

Robertson, & Ulrich, D. (1998). Planning for product platforms.

Roland Berger. (2012, November 1). Mastering product complexity. Retrieved March 5, 2016, from

Roland Berger. (2014, December 10). Global Automotive

Supplier Study:Record Profits Versus Increasing

Volatility. Retrieved November 5, 2015, from https://www.rolandberger.com/media/pdf/Roland_Berger_Global_Automotive_Supplier_Study_20141209.pdf

Romme, A. G. L. (2003). Making a Difference: Organization as Design. *Organization Science*, *14*(5), 558–573. http://doi.org/10.1287/orsc.14.5.558.16769

Rothaermel, F. T. (2001). Incumbent's advantage through exploiting complementary assets via interfirm cooperation. *Strategic Management Journal*, *22*(6-7), 687–699. http://doi.org/10.1002/smj.180

Rothaermel, F. T., & Hess, A. M. (2007). Building Dynamic Capabilities: Innovation Driven by Individual-, Firm-, and Network-Level Effects. *Organization Science*, *18*(6), 898–921. http://doi.org/10.1287/orsc.1070.0291

Rothaermel, F. T., Hitt, M. A., & Jobe, L. A. (2006). Balancing vertical integration and strategic outsourcing: effects on product portfolio, product success, and firm performance. *Strategic Management Journal*, *27*(11), 1033–1056. http://doi.org/10.1002/smj.559

Sampson, R. C. (2007). R&D ALLIANCES AND FIRM PERFORMANCE: THE IMPACT OF TECHNOLOGICAL DIVERSITY AND ALLIANCE ORGANIZATION ON INNOVATION. *Academy of Management Journal*, *50*(2), 364–386. http://doi.org/10.5465/AMJ.2007.24634443

Sanchez, R., & Mahoney, J. T. (1996). Modularity, flexibility, and knowledge management in product and organization design. *Strategic Management Journal*, *17*(S2), 63–76. http://doi.org/10.1002/smj.4250171107

Schilling, M. A. (2000). Toward a General Modular Systems Theory and Its Application to Interfirm Product Modularity. *Academy of Management Review*, *25*(2), 312–334. http://doi.org/10.5465/AMR.2000.3312918

Schumpeter, J. A. (1934). The theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle, *55*.

Schumpeter, J. A. (1942). Capitalism and the Process of Creative Destruction. *Monopoly Power and Economic Performance*, 19–38.

Sethi, R. (2013). New Product Quality and Product Development Teams. *Dx.Doi.org*, *64*(2), 1–14. http://doi.org/10.1509/jmkg.64.2.1.17999

Shapiro, C. (1982). Consumer Information, Product Quality, and Seller Reputation. *The Bell Journal of Economics*, *13*(1), 20. http://doi.org/10.2307/3003427

Shapiro, C. (1983). Premiums for High Quality Products as Returns to Reputations. *The Quarterly Journal of Economics*, *98*(4), 659.

Sherefkin, R., & Armstrong, J. C. (2003). Suppliers wary of increasing warranty charges. *Automotive News*, 17.

Shingo, S., & Dillon, A. P. (1989). A study of the Toyota production system: From an Industrial Engineering Viewpoint.

Simon, H. A. (1962). The Architecture of Complexity. *Proceedings of the American Philosophical Society*, *106*(6), 457–476. http://doi.org/10.1007/978-1-4899-0718-9_31

Sirmon, D. G., & Lane, P. J. (2004). A model of cultural differences and international alliance performance. *Journal of International Business Studies*, *35*(4), 306–319. http://doi.org/10.1057/palgrave.jibs.8400089

Slater, S. F. (1996). The challenge of sustaining competitive advantage. *Industrial Marketing Management*, *25*(1), 79–86.

Slater, S. F., & Narver, J. C. (1998). Research notes and communications customer-led and market-oriented: Let's not confuse the two. *Strategic Management Journal*.

Smith, P., & Reinertsen, D. (1991). Developing Products in Half the Time. New York: an Nostrand Reinhold.

Song, M., & Di Benedetto, C. A. (2008). Supplier's involvement and success of radical new product development in new ventures. *Journal of Operations Management*, *26*(1), 1–22. http://doi.org/10.1016/j.jom.2007.06.001

Song, M., & Thieme, J. (2009). The Role of Suppliers in Market Intelligence Gathering for Radical and Incremental Innovation *. *Journal of Product Innovation Management*, *26*(1), 43–57. http://doi.org/10.1111/j.1540-5885.2009.00333.x

Sosa, M. E., Eppinger, S. D., & Rowles, C. M. (2003). Identifying modular and integrative systems and their impact on design team interactions. *Journal of Mechanical Design*, *125*(2), 240–252.

Stuart, T. E. (2000). Interorganizational alliances and the performance of firms: a study of growth and innovation rates in a high-technology industry. *Strategic Management Journal*, *21*(8), 791–811. http://doi.org/10.1002/1097-0266(200008)21:8<791::AID-SMJ121>3.0.CO;2-K

Taj, S. (2008). Lean manufacturing performance in China: assessment of 65 manufacturing plants. *Journal of Manufacturing Technology Management*.

Takeishi, A. (2001). Bridging inter- and intra-firm boundaries: management of supplier involvement in automobile product development. *Strategic Management Journal*, *22*(5), 403–433. http://doi.org/10.1002/smj.164

Tatikonda, M. V., & Montoya-Weiss, M. M. (2001). Integrating Operations and Marketing Perspectives of Product Innovation: The Influence of Organizational Process Factors and Capabilities on Development Performance. *Management Science*, *47*(1), 151–172. http://doi.org/10.1287/mnsc.47.1.151.10669

Teece, D. J. (1996). Firm organization, industrial structure, and technological innovation. *Journal of Economic Behavior & Organization*, *31*(2), 193–224. http://doi.org/10.1016/S0167-2681(96)00895-5

Teece, D. J. (2000). Strategies for Managing Knowledge Assets: the Role of Firm Structure and Industrial Context. *Long Range Planning*, *33*(1), 35–54. http://doi.org/10.1016/S0024-6301(99)00117-X

Teece, D. J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal*, *28*(13), 1319–1350. http://doi.org/10.1002/smj.640

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic Capabilities and Strategic Management. *Strategic Management Journal*, *18*, 509–533. http://doi.org/10.2307/3088148

Ulrich, K. (1995). The role of product architecture in the manufacturing firm. *Research Policy*, *24*(3), 419–440. http://doi.org/10.1016/0048-7333(94)00775-3

Ulrich, K. T. (2003). Product design and development.

Utterback, J. M., & Abernathy, W. J. (1975). A dynamic model of process and product innovation. *Omega*, *3*(6), 639–656.

Utterback, J. M., & Suarez, F. F. (1993). Innovation, competition, and industry structure. *Research Policy*, *22*(1), 1–21. http://doi.org/10.1016/0048-7333(93)90030-L

van Echtelt, F. E. A., Wynstra, F., van Weele, A. J., & Duysters, G. (2008). Managing Supplier Involvement in New Product Development: A Multiple-Case Study. *Journal of Product Innovation Management*, *25*(2), 180–201. http://doi.org/10.1111/j.1540-

5885.2008.00293.x

Viereckl, D. R., Ahlemann, D., Koster, A., & Jursch, S. (2015). Racing Ahead with Autonomous Cars and Digital Innovation. *Auto Tech Review*, *4*(12), 18–23. http://doi.org/10.1365/s40112-015-1049-8

Villalonga, B., & Mcgahan, A. M. (2005). The choice among acquisitions, alliances, and divestitures. *Strategic Management Journal*, *26*(13), 1183–1208. http://doi.org/10.1002/smj.493

Wagner, S. M., & Hoegl, M. (2006). Involving suppliers in product development: Insights from R&D directors and project managers. *Industrial Marketing Management*, *35*(8), 936–943. http://doi.org/10.1016/j.indmarman.2005.10.009

Weber, J. (2009). Automotive Development Processes. Berlin, Heidelberg: Springer Science & Business Media. http://doi.org/10.1007/978-3-642-01253-2

Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal*, *5*(2), 171–180. http://doi.org/10.1002/smj.4250050207

Whitford, J., & Zirpoli, F. (2014). Pragmatism, Practice, and the Boundaries of Organization. *Organization Science*, *25*(6), 1823–1839. http://doi.org/10.1287/orsc.2014.0919

Williamson, O. (1985). The Economic Institutions of Capitalism. Firms, Markets, Relational Contracting. New York: Free Press.

Williamson, O. E. (1975). Markets and hierarchies, analysis and antitrust implications. Free Press. Retrieved from http://books.google.com/books/about/Markets_and_hierarchies_analysis_and_ant.html?id=21i3AAAAIAAJ&pgis=1

Williamson, O. E. (1983). The vertical integration of production: market failure considerations. *The American Economic Review*, (73), 519–540. http://doi.org/10.2307/1816983

Winter, S. G. (2003). Understanding dynamic capabilities. *Strategic Management Journal*, *24*(10), 991–995. http://doi.org/10.1002/smj.318

Wolter, C., & Veloso, F. M. (2008). The Effects of Innovation on Vertical Structure: Perspectives on Transaction Costs and Competences. *Academy of Management Review*, *33*(3), 586–605. http://doi.org/10.5465/AMR.2008.32465693

Womack, J. P., Jones, D. T., & Ross, D. (1990). The Machine That Changed the World. New York: Rawson/Harper Perennial. Retrieved from http://books.google.com/books?hl=pt-BR&lr=&id=dP_c3EZwUusC&pgis=1

VITA

JOSÉ-MAURÍCIO GALLI GELEILATE

EDUCATION

Ph.D. in Business Administration (expected Spring 2016) – Florida International University.

MBA in Finance (2012) - Fundação Getulio Vargas / FGV (AACSB accredited)

Masters degree with focus on Strategy (2011) - Universidade de Fortaleza

Bachelor in Business (2008) - Universidade Federal do Ceará

PEER REVIEW PUBLICATIONS

Dunlap, D. Parente, R. Geleilate, J.M, Marion, T. (2016). Organizing for Innovation Ambidexterity in Emerging Markets: Taking Advantage of Supplier Involvement and Foreignness. *Journal of Leadership and Organizational Studies.*

Parente, R. Geleilate, J. M. (2015). Developing New Products in the Automotive Industry: Exploring the Interplay between Process Clockspeed and Supply Chain Integration. *Industrial and Corporate Change.*

Herrera-Echeverri, H., Geleilate J. M., Gaitan-Riaño, S., Haar, J., Soto-Echeverry, N., (2015). Export behavior and board independence in Colombian family firms: A virtuous cycle. *Journal of Business Research*.

Geleilate, J., & Forte, S. (2012). Motivações e estratégias de internacionalização dos três maiores bancos brasileiros frente à nova configuração econômica mundial. *Revista Portuguesa e Brasileira de Gestão, 11*(1), 02-12.

Oliveira, M. C., Ponte, V. M. R., De Luca, M. M. M., de Oliveira, O. V., Aragão, L. A., & Geleilate, J. M. G. (2013). Corporate governance practices and conformity to capital market demands in privately traded brazilian companies. *BASE-Revista de Administração e Contabilidade da Unisinos, 10* (3).