Product biographies in servitization and the circular economy

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Keywords: products, service, servitization, product biography, circular economy, Internet of things, repair

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1. Introduction

The pursuit of service-led growth by product firms has been an increasingly important issue for practice, research and policy over the past ten to fifteen years. Early research on the shift to services, or 'servitization' was largely conceptual, arguing for servitization as such (Vandermerwe and Rada, 1988), and in manufacturing in particular (Wise and Baumgartner, 1999), as a way to differentiate and to create and/or capture extra value. Subsequently, an extensive literature has grown around the categorisation of different forms of service-led growth in product firms (Mathieu, 2001; Tukker, 2004; Matthyssens and Vandenbempt, 2010; Kindström and Kowalkowski, 2014; Kowalkowski et al., 2015), often centring on whether and how service activities should be related to the associated products and, in some cases, examining alternative forms of ownership structure and their effects (Snir, 2001; Stoughton and Votta, 2003). Manufacturing firms venturing into service provision face challenges in terms of organisational structure (Galbraith, 2002; Raddats and Burton,

2011; Gebauer et al., 2010) and in developing functional strategies, for example in marketing and operations (Matthyssens and Vandenbempt, 2008; Baines et al., 2009). An enduring question is the extent to which service should be provided from the same organisational unit as production, or delivered from a separate one (Oliva and Kallenberg, 2003; Oliva et al., 2012). Others have examined the role of capabilities in enabling firms to put servitization strategies into effect (Ulaga and Reinartz, 2011; Spring and Araujo, 2013), identifying how existing capabilities can be mobilised, and what additional capabilities may need to be developed or accessed from other firms in the network.

As servitization has become increasingly widely advocated and adopted, researchers have turned their attention to its financial and performance implications (Neely, 2008; Visnjic-Kastalli and Van Looy, 2013; Eggert et al., 2014). The so-called 'servitization paradox' has emerged, which suggests that firms who adopt servitization may grow their revenue, but not their profit (Neely, 2008). More specifically, studies have begun to show that firms perform better when they add a large proportion of service offerings to their manufacturing product offering, rather than adding services only in a very incremental fashion (Fang et al., 2008). In some forms of servitization, the manufacturer retains ownership of the product and makes it available to the customer using some form of lease, rental or payment for access. This is also examined in the systems integration and 'solutions' literature (Prencipe et al., 2003; Nordin and Kowalkowski, 2010). As such, another strand of literature has examined the different forms these arrangements may take, using, for example, property rights theory (Lay et al., 2009) and agency theory (Kim et al., 2007) to understand how the change in ownership structure alters incentives in the 'servitized' relationship.

In these various ways, the embracing of services has certainly presented new challenges in practice and in theory. Product-led firms have had to develop or access new capabilities; researchers have had to think again about what services are, often without the aid of the conventional, externally-imposed categorisations of 'service sectors' that had defined the scope of most service research hitherto. But in this search for insight into what services are, why that matters, and, especially, how it matters to product-led firms, we suggest that the product has been neglected. As we demonstrate, products have been treated as the stable, unproblematic element in the mix, as vehicles for the delivery of service, as the part of the business that is relatively familiar and easy to manage.

We suggest, on the contrary, that the intimate entangling of products and services in many forms of servitization means that we must reflect as intensively on the nature, role and identity of products as we do on those of services. Further still, as the conventional take-make-dispose model of product supply chains is superseded by what is increasingly known as the 'circular economy', the identity and stability of products is challenged even more, as they undergo refurbishment, remanufacturing,

dismantling, re-use and recycling, as well as being subject to new forms of valuation and exchange. Although it has recently been discussed in policy, consultancy and the human geography literature (WEF, 2014; Nguyen et al., 2014; Hobson, in press), the circular economy has not been addressed in industrial marketing, despite its potentially profound implications for business-to-business networks and relationships. Finally, the emerging phenomenon of the 'Internet of things' potentially allows constant monitoring, adjustment and redefinition of products and their relationships to other actors and artefacts in a network. Taken together, these developments suggest that it is necessary to reconsider the product. Existing conceptualisations position it as a stable entity in a producer-centric, linear distribution chain; we suggest a more distributed conceptualisation of products, seeing them as open-ended propositions subject to constant re-definition and re-valuation as they are attached to and detached from successive contexts and networks.

To do this, we use the central idea of the product biography to examine products in relation to services, to other products, and in processes of production, re-production, valuation, exchange and use. Our aim is to use the product biography perspective to disrupt the conventional views of products in servitization, in order to reveal novel insights. The circular economy context is used to examine some of the implications of the product biography approach in settings where the scope of - and the need for - service-based innovations is particularly evident. In the next section, we review how the product has been conceptualised in the servitization and general marketing literature. Next, we introduce the central concept of the paper, the product biography, and link this to the associated need for qualification and valuation processes. In section 4, the notion of the circular economy is introduced more fully, and its implications for product qualification and network reconfiguration are examined through two illustrative case studies. Section 5 then develops the argument that various forms of repair – in many ways at the heart of the circular economy – should be seen not just as occasions for restoration of products, but also as opportunities for innovation and entrepreneurial action. We then discuss the implications for servitization of the product biography view and our application of it to the circular economy context. Section 7 summarises the contributions of the paper.

2. Servitization and the product

Any analysis of service-led growth by product firms – which we will refer to as 'servitization' for convenience – has to consider various aspects of the service activities that product firms begin to undertake. The servitization literature has done just this, and some of the service issues considered

are outlined in the Introduction. The conceptualisation of the product is, by comparison, much less frequently discussed. In this section, we review how the product has been treated in, first, the general marketing literature, then the servitization literature. This provides a basis for our argument that a product biography perspective can provide new insights into servitization.

2.1 Concepts of the product in marketing

The general marketing literature has generally struggled to conceptualise products beyond commonsense notions. Kotler (1967: 289) defined a product as "a bundle of physical, service and symbolic particulars expected to yield satisfaction or benefits to the buyer". Similarly, for Corey (1975: 121) "…the product is what the product does: it is the total package of benefits the customer receives when he buys". Later, Kotler (1980: 352) simplified this definition to a product being ". . . simply the packaging of a problem-solving service". Riddle (1986: 4), following the Kotlerian vein, noted that: "tangible objects... have little value in and of themselves; they are important only to the extent that they serve as the equipment and supplies for the extraction or service production processes".

The services marketing literature provides brief definitions of the product, before proceeding to contrast the characteristics of products and services. Grönroos (1998: 352) defined a product as a "…more or less pre-produced package of resources and features that is ready to be exchanged." In their quest to move away from a product-centred logic, Vargo and Lusch (2004: 9) similarly claim that products are ". . . best viewed as distribution mechanisms for services", or "carriers of competence" (Michel et al., 2008); this finds a parallel in Normann's notion of the offering as 'frozen knowledge' (Normann, 2001: 116).

Modular design of products (Baldwin and Clark, 1997; Sanchez and Mahoney, 1996; Salvador, 2007), sometimes allied with mass customisation (Pine, 1993), offers the potential to configure and re-configure products. In that sense, modularity may suggest a kind of flexibility in product specification. But modularity is predominantly a way to offer a wider variety of 'pre-produced package[s] of resources and features' which, once chosen, remain just as stable as any other product as conceived in the general marketing literature. Modular architecture allows such variety to be achieved without incurring disproportionate extra cost (this is particularly the emphasis of the mass customization literature), but this mainly affects the economics of production, rather than fundamentally altering the nature of the product once made.

These views share a number of points in common. First, products are seen as stabilised bundles of attributes that have been packaged together through manufacturing processes. Secondly, products present themselves as sets of objective characteristics that may be differentially valued by different potential buyers. And finally, once purchased, products acquire value through use, as platforms for delivering services to users.

2.2 The product in servitization

The servitization literature has developed most of its key concepts on services and their management relative to particular, if often implicit, notions of the product. The provision of services to support an 'installed base' of capital products has been a prominent theme in the literature from its early days: this is explicitly or implicitly the scenario addressed by Potts (1988), Wise and Baumgartner (1999), Oliva and Kallenberg (2003) and Davies (2004), for example. In these conceptions, the product is in the field and the proposition is that there is profit to be made from providing services for the years or even decades of its use and that the manufacturer, by virtue of having made the product, should be well placed to provide such services. The challenge for the manufacturer is typically presented as a question of whether it can find the right organisational, process and cultural ingredients to deliver services as well as manufacture products. Amidst these considerations, the product is conceptualised as having a product life-cycle that is given and inevitable, moving through a succession of stages, usually defined from the manufacturer's perspective. For example, a recent review of the concept of life-cycle service offerings (Rabetino et al., 2015) presents a typical life-cycle model as consisting of four phases - pre-sales, sales, post-sales and de-commissioning - and seeks to slot manufacturers' service offerings into one or more of these phases. The product, and the life-cycle that it sets in train, is treated as a stable backdrop against which the offer of various service elements can be configured.

Services have often been categorised as being either product-related or not: Oliva and Kallenberg (2003), for example, separate services into 'product-oriented' and 'end-user's process-oriented'. The shift to the latter entails the development of new capabilities and structures that 'may resemble those of professional service firms' (Oliva and Kallenberg, 2003: 169). This distinction endures in Rabetino et al.'s (2015) recent review of 'life-cycle' services. The concept of the product here is one of familiarity: it is the pseudo-professional-services that require the manufacturing firm to develop new capabilities, new contacts with different parts of the customer's organisation, and effective ways to price and sell the newly-defined service offerings.

In some forms of servitization, the manufacturer retains ownership of the product (Windahl and Lakemond, 2010), with the customer paying for access or performance. In this respect, the product is implicitly conceptualised as a collection of property rights, an asset of a certain capacity at risk of being under- or over-used, or under- or over-priced (Lay et al., 2009). Retention of ownership is a source of incentives for the manufacturer to improve availability and performance, and reduce operating costs; such incentives may be sharpened by being framed in performance-based contracts (Kim et al., 2007; Selviaridis and Norrman, 2014).

Another prominent thread in servitization research is concerned with the further understanding of the capabilities required to shift to service. Ulaga and Reinartz (2011) adopt the resource-based view to identify the resources and capabilities required for manufacturing firms to develop and deliver 'hybrid' offerings. Although they treat 'hybrid' offerings as 'products and services combined into innovative offerings' (ibid: 5), they do not discuss products as such. Products are only present in this account in the shadows they cast on organisational resources and capabilities: because manufacturing firms have an installed base of products, there is likely to be data about their usage; because manufacturing firms produce products, they have product development and manufacturing assets, and so forth.

In summary, products have been seen as largely stable entities imbued by the manufacturer with competences or 'frozen knowledge', entering into the customer's domain to provide pre-defined 'problem solving services'. Even in the modularity literature, which admits of some flexibility in the product form, such flexibility is on the manufacturer's terms, and really only consists of choice among pre-defined alternative 'pre-produced package[s] of resources and features' e.g. Sanchez and Mahoney (1996). Products enter the servitization domain as implicit signifiers of firms' competences in production and product design (and, hence, signifiers of a lack of competence in services), and as carriers of their own inevitable life-cycles, into which service offerings can be inserted. The product itself is simultaneously taken for granted and never really present.

3 Product biographies and servitization

Since the existing servitization literature offers a rather limited account of the product, we draw on conceptualisations from outside the marketing discipline to provide alternative insights. In particular, we adopt anthropologist Igor Kopytoff's notion of the 'biography' of products.

3.1 Product biographies

Kopytoff (1986) suggests that economists (and, we might add, marketers) see commodities as self-evident objects, that 'simply are', circulating within economic systems by virtue of having use and exchange values. In contrast, anthropologists are concerned with the cultural, social and material dimensions of things, how they are singularised through use. Objects must be produced but also categorised, qualified as being a particular object. In this sense, the biography of a thing is in large part about "…the various singularisations of it, of classifications and reclassifications in an uncertain world of categories whose importance shifts with every minor change in context" (Kopytoff, 1986: 90). Kopytoff argues that such a process, in complex societies, is a continuing tension between commoditization and singularization, between being just another example of a particular class of objects and being a particular, unique specimen.

The notion of product biographies is well known in consumer research (see, for example, Epp and Price, 2010). The information systems literature has also used it to explain how objects such as ERP (enterprise resource planning) systems gradually evolve in interaction with specific organisational settings as well other information systems and organisations (see e.g. Pollock and Cornford, 2004; Locke and Lowe, 2007). But, to our knowledge, it has never been used in the industrial marketing literature. We propose, therefore, to see products through their biographies, as evolving sets of characteristics or qualities. These qualities are obtained through what Callon et al. (2002) describe as qualification processes. As they put it: "Talking of quality means raising the question of the controversial processes of qualification, processes through which qualities are attributed, stabilized, objectified and arranged" (ibid: 199).

Czarniawska and Mouritsen (2009) make a broader point about how organisations deal with technological artefacts, not as singular material objects, but through what they call management technologies. They suggest that:

> "…up close, material objects are frightening: their cold shape impresses but also inhibits management – they are too concrete and firm. Managers want things to be mouldable, so that they can be reformed and transformed to new uses" (Czarniawska and Mouritsen, 2009: 158)

Management technologies are thus mediators, turning material objects into representations or manageable objects. Thus, for example, complex, concrete, multi-faceted human employees become 'human resources' that can be managed in respect of one or a few key parameters – salary cost, highest qualification, training courses completed. Likewise a machine used in production

becomes an item in an asset register, a production capacity in a planning system, or a depreciation charge in an accounting system. At the moment of management intervention, the singular employee or machine becomes a commoditized quantity of skill or capacity, to be combined with or compared to other commoditized quantities. This view underlines the role of inscription and calculation in the construction of the product biography.

3.2 Products and goods

As well as taking take place within organisations, through a variety of management technologies, qualification also takes place through market processes when products are traded in a variety of forms. In this regard, the notion of product biographies allows Callon et al. (2002) to make a helpful distinction between products and goods. In the course of its biography, encompassing design, production, circulation, consumption or use, and end of life, a product undergoes a multitude of operations that transform its characteristics. The concept of a good, on the other hand, implies the stabilisation of the characteristics associated with the product, which allows it to be traded. It applies to services as well as products – as we have argued elsewhere (Araujo and Spring, 2006) - and each stabilisation depends on the specific institutional context of the exchange. Furthermore, as Callon et al. (2002) note, the product, looked upon as such a trajectory of transformations, describes the different networks that coordinate the actors involved in its design, production, distribution and use. This takes us away from the notion that products are injected with characteristics and value through manufacturing processes, those characteristics remaining unchanged save for wear and tear as well as the occasional breakdown (Crang et al., 2013).

Callon et al. (2002) use the example of a car model to illustrate this argument. A car model starts life as a set of drawings and specifications, then a complete design and a prototype, before it is ready for road and other tests (e.g. emissions). If successful, it becomes a bill of materials, a set of system and component specifications to be passed on to suppliers and manufacturing plants, before a whole assembly line and supply chain are put together. Only then does it appear in catalogues, with a stabilised set of specifications for each variant, ready to be ordered from dealerships. Each individual new car is given a specific identity (e.g. chassis and engine number, property title, license plates) which allows it to be singularised and traced as a unique entity. At each stage, the characteristics of the car as a good are being defined and refined, qualified through a battery of tests, measurement instruments, certifications and so on. The salient characteristics change: for example, those established through road tests do not migrate to sales brochures untouched even if the two are obviously related. The process of qualification involves significant investments in a socio-technical

infrastructure, some external to the car assembler (e.g. crash tests by independent laboratories). And, qualification continues beyond this point (e.g. car journalists, consumer reports).

Once a new car is on the road, it accumulates miles on the clock and routine wear and tear, as well as undergoing both routine and emergency repairs. These are important parts of its biography. When the first owner comes to sell it as a used car, it is necessary to stabilise it and change it into a good, by defining its mileage, taxation status, condition, maintenance history and so on, in order that prospective owners can compare it with other used cars for sale, and thereby value it accordingly. In this way it can be detached from one network and then embedded in another – commoditized and then de-commoditized, once again.

This process constitutes a reciprocal relationship: the product identifies the agents involved in its transformations, tracing a specific network, while those same agents, through mutual adjustments and iterations, gradually establish the product's qualities. Products' qualities are thus always open and liable to revision, as they are detached from one network and attached to another. Adopting this perspective to look at servitization, we suggest that, rather than being stable, unproblematic objects – objects that 'simply are' - products are less stable than we might think. They may change physically, while maintaining stability of classification, or they may remain stable physically while being re-classified and re-qualified; or these changes may occur in combination. The alternation of the product between a taken-for-granted, concrete artefact that is used in organisational practices and its moments as a problematized, qualified and valorised managerial object or good echoes the distinction made by Heidegger between a thing being 'present-at-hand' (*Vorhanden*) and 'ready-to-hand' (*Zuhanden*) (Harman, 2010). When 'ready-to-hand', the thing ceases to be an object of explicit consideration, so long as it continues to work. Furthermore, it becomes part of 'equipment'; there can be no such thing as *an* equipment, but inter-connected things that are mutually 'constituted by their involvements from the start' (Harman, 2010: 19). When 'present-at-hand', things become 'obtrusive': they break down, they 'announce themselves' and become objects of deliberate contemplation. Taken together, these processes of qualification, commoditization and de-commoditization constitute critical moments in the product biography and, moreover, the moments of hesitation and flux when service offerings can be generated.

3.4 Contrasting existing perspectives with the product biography view

The conceptualisation of products in the existing servitization and marketing literatures, as discussed in section 2, contrasts markedly with the product biography and related perspectives just outlined.

The main areas of divergence are summarised in Table 1: columns I and II summarise the threads of literature that we have discussed previously, including indicative references, whereas column III takes the principles of the product biography approach and teases out their possible implications for each notion of the product in column I. In all these aspects, the product biography approach brings the singular product back into view, it emphasises process rather than state, and stresses a distributed, networked and shifting qualification process rather than a producer-centric, stable conceptualisation of the product. Some of these points are now expanded upon a little further.

The view of products as the "packaging of a problem-solving service" (Kotler, 1980) assumes that product designers know *ex-ante* the range of problems users will face and that the appropriate solutions can be packaged in one artefact. In this view, users play a passive role, limited to extracting the value packaged in a product by manufacturers. By contrast, the product biography view suggests that no such stability can be assumed. The value and use of a product depends entirely on the user's network to which it is attached. Moving the product from one user's network to another requalifies and reclassifies the product and reciprocally, the product changes the new user network to which it is attached.

The notion of a product as "frozen knowledge" (Normann, 2001) or a "carrier of competence" (Michel et al, 2008) is another instance of privileging the manufacturer's view and the idea that manufacturing processes inject value, knowledge and competences in a product. The notion of product biography stands in stark contrast to this view. Seeing product biography as the multiple and distributed qualification processes questions the idea that artefacts can unproblematically capture, incorporate or transfer competences. Instead, a biography approach stresses that knowledge and competences are evident in the making and the using of products, and evolve as new ways of classification and qualification are devised.

Finally, the concept of product biography is linked to the career of singular objects and it should not be confused with the notion of product life-cycles, which has a different progeny and aim. Life-cycles describe generic stages - conception, birth, maturity, death – with implications for managing each stage. Biographies are particular to individual specimens, multifaceted, and are about connections – connections to other things, to practices, to people and organisations.

Table 1 – Products in marketing and servitization compared to the product biography perspective

I **Product conceptualisations**	II **Existing marketing and servitization literature**	III **Product biography approach**
Product life-cycle e.g. Rabetino et al. (2015)	Generalised product passes through sequential, inevitable stages. Within each stage, key parameters remain constant. Mechanisms/markers for transition from each stage not discussed. Service strategies/ offerings chosen for each stage.	The particular product specimen makes and is made by episodes that are institutionally and textually manifest: these are episodes of qualification, valuation, comparison, classification.
Product-related/non-product related services e.g. Oliva and Kallenberg (2003)	In Oliva &Kallenberg, product-related services are mostly associated with initial embedding of capital equipment in customer organisation; also some subsequent spares and maintenance. Implication is that these are easier because of manufacturer's knowledge of the product.	Entrepreneurial opportunities for services/service innovation attach to transitions and qualifications. In some senses, that is what Oliva & Kallenberg discuss. But so-called non product-related services are part of making products manageable and are indeed processes of qualification themselves ('management of spares' etc.) The biography links the physical to the organisational and back. Finance services derive from valuation; 'management' – of capital asset, spares, etc – requires writing the asset/spare into an organisation (ERP system, accounting system) and can thus be seen as inscribing the product biography.
Product ownership e.g. Lay et al.(2009)	Nature of ownership by manufacturer and user determines residual rights and therefore competence and incentive to act for the 'most efficient' outcome. The state of ownership is all that matters.	Attachment to and detachment from networks of other objects, people, organisations affect the subjective interpretation of the product's role relative to the particular actor. This is only temporarily fixed. The process of attachment and detachment is of as much (more?) interest as the steady state.
Products as markers for resources and capabilities e.g. Ulaga and Reinartz (2011)	The very fact of being a product firm/manufacturer implies the possession of or access to manufacturing-related resources and capabilities. These may be of use, or may be an impediment to, the development and deployment of assets and capabilities supposedly required for services.	Insofar as resources and capabilities play any part in this conceptualisation, they would become manifest in particular practices relating to particular products as they connect to other products and actors. ……..
Products are '….simply the packaging of a problem-solving service' (Kotler, 1980)	Stresses the view that products are 'appliances' with which customers create value for themselves. 'Packaging' suggests once-and-for-all stability; 'problem-solving' suggests that the problem to be solved is known *ex ante.* The product is stable and passive; the user is the active participant who 'extracts value'.	The 'packaging' is a temporary stabilisation. Attachment to the user's network re-qualifies and reclassifies the product, and its presence redefines the user and associated network. The package changes, the nature of the problem changes.
Products as 'frozen knowledge' or 'carriers of competence' e.g. Normann (2001), Michel et al. (2008)	Emphasises the producer view. The knowledge and competence that is frozen and carried is that of the producer and its network. Admits of no learning.	Seeing biography as a process of multiple and distributed qualification calls into question the idea of anything being 'frozen', and the notion that competence can be captured and transported intact and stable. Rather, knowledge and competence are distributed and evident in the making, in the using, and are constructed by users, other actors and systems of qualification.

4. Products in the circular economy

The dominant marketing and servitization conceptions of the product discussed above have been developed in the context of a producer-centred, linear economy. In marketing in general, and in most prior treatments of products in the servitization literature, this has led to such framings as product life-cycles that are given and unidirectional, a dominant concern with the capabilities of manufacturers rather than those of a wider network, products that constitute frozen embodiments of the producer's knowledge, and so on. Some forms of servitization begin to question the necessity for the user to own the product but, as Rabetino et al. (2015) point out, such 'advanced' forms of servitization are relatively rare.

However, the linear model is increasingly untenable, as environmental pressures and material scarcity stimulate interest among industry, policy and academic communities in what is becoming known as the circular economy (Mulgan, 2013; Nguyen et al., 2014; Yuan et al., 2006; WEF, 2014). Rather than a linear 'take-make-dispose' model of production and consumption, 'a circular economy is one that is restorative by design, and which aims to keep products, components and materials at their highest utility and value at all times' (Ellen MacArthur Foundation, 2015).

Here, we suggest that considering the implications of the circular economy in the extended - and possibly very varied - biographies of products can add significantly to our understanding of service-led growth in product firms. The logic of the circular economy requires us to give, if not primacy, equal status and attention to reverse as to forward flows; it also draws attention to the relative immaturity of the systems of qualification of products and materials flowing in the reverse direction as compared to those in the linear, forward flow. Such systems are not only relatively immature, but have greater demands placed upon them by the inherently entropic nature of production, distribution and use: product biographies tend to diverge.

In this way, exploring the circular economy offers a way to think innovatively about products in the context of servitization. In this section, we outline the basic tenets of the circular economy concept and the requirements for institutional change that it entails. We then draw on secondary sources to examine two cases that demonstrate different aspects of this reconfiguration of networks, qualification processes and institutions.

4.1 The circular economy concept

The World Economic Forum (WEF) report (2014), "Towards the Circular Economy: Accelerating the scale-up across global supply chains", remarks that the linear model of take, make, and dispose has been dominant since the early days of industrialisation. This is replicated in academic models such as

value or supply chains, which regard all stages of a chain as adding value while the endpoint, consumption, is a "value sink" (Normann, 2001). As we have suggested, it also shapes the dominant conceptualisations of the product. The circular economy is designed to eliminate waste through cycles of assembly, use, disassembly and re-use, with virtually no leakages from the system in terms of disposal or even recycling (see Figure 1), and replaces the habitual notion of a consumer, who owns things and destroys value, with that of a user. The concept was set out by Walter Stahel 40 years ago (Stahel and Reday, 1976/1981), but has recently been given added impetus by think-tanks such as the Ellen MacArthur Foundation, consultancies (Nguyen et al., 2014) and, increasingly, policy initiatives (Yuan et al., 2006; Spring, 2013).

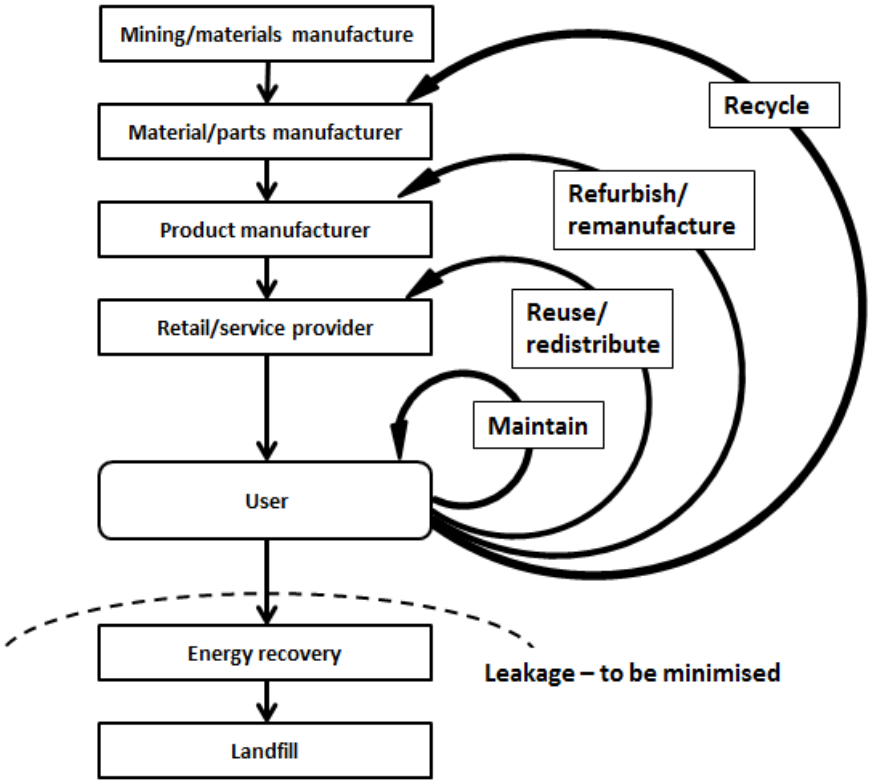

Figure 1: The circular economy (adapted from Ellen MacArthur Foundation)

Some aspects of the circular economy model, especially the shift to paying for performance and access rather than ownership, will be familiar to servitization scholars. Indeed, the strand of management literature examining access-based servitization used the term 'product-service systems' (PSS), taken explicitly from earlier studies in industrial ecology (Mont, 2002); these, in turn, drew on Stahel (1976/1981). Baines et al.'s review (2007) acknowledges and describes these origins

in industrial ecology, and Tukker (2004) discusses both environmental and strategic logics. But most of the managerial literature - including other research by Baines and his colleagues - has played down the environmental motivation, even if the 'product-service-system' label has sometimes been useful to apply to the emerging technical and institutional arrangements that had sprung up for largely commercial and strategic reasons. However, the interest shown recently in the circular economy by the consultants McKinsey (Nguyen et al., 2014) suggests that businesses increasingly see convergence between environmental and business motivations. This is consistent with the growing acceptance of the compatibility, rather than conflict, between performance on financial and sustainability dimensions respectively (Golicic and Smith, 2013; Carter and Easton, 2011). As such, we re-unite the environmentally-inspired PSS strand in the form of the circular economy with the managerial emphasis on service-led growth, in order to gain insights into the managerial implications for product firms.

4.2 Institutions and qualification in the circular economy

Servitization often requires institutional change, especially in access- or performance-based models , where the manufacturer retains ownership of a piece of equipment and property rights must therefore be delineated anew (Lay et al., 2009), along with arrangements for payment, performance management and the like. In the same way, only on a much more extensive basis, the implementation of a circular economy requires technological change but also institutional innovation (cf Mont, 2004). Institutional change is required to allow: products to be accessed and shared as well as sold outright; products, components and materials to be categorized, sorted and treated accordingly when they are returned from a context of use; and in various other ways to handle the unfamiliar reverse flows, re-manufacturings and repairings, and non-ownership-based usage models that are part and parcel of the circular economy concept. Indeed, the World Economic Forum identifies three 'leakage points', factors that militate against the adoption of the circular economy: geographic dispersion of manufacturers and suppliers; materials complexity and proliferation; and 'lock-in' to a linear economy model (WEF, 2014: 29). The last of these is especially an institutional problem.

The reverse flows that are the essence of the circular economy require additional processes of qualification, of intact products, of sub-assemblies and components, and of constituent materials, so that this 'lock-in' can be overcome, and the reverse and circular flows can become as normal and efficient as forward, linear flows. Qualification is required first to determine that a product or

component is in need of repair or replacement, and then to determine what courses of action to take at each stage, as products are recovered from end-users, moved to points of disposal, and the most economically attractive and technically feasible reuse option determined. Qualification is also essential to the creation of markets for refurbished or remanufactured goods. Products' biographies may be forgotten, unmentioned and unproblematised, until reaching critical points where they 'come to the surface' or 'announce themselves', presenting a problem of categorisation, qualification, classification: 'What is this?' 'What can/can't I do with it? Who owns it? Who is liable?' It is still an electric motor, a piece of wood, or platinum, but, having journeyed so far from its original incorporation into a product and, presented at the point of dismantling, repair or recycling, its provenance may be lost, the effects of its journey unknown, and the implications for what to do next, consequently, unclear. The risk – environmentally speaking if nothing else – is that, without effective qualification processes, the 'safe' option of disposal will be favoured over re-use or other 'circular' options: in other words, quality uncertainty (cf. Akerlof, 1970) will cause failure in the processes that constitute the circular flow (see also Neyland and Simakova, 2012).

4.3 Configuring the network for a circular economy: two cases

To illustrate these institutional and qualification aspects of the circular economy, we present and discuss two case studies, drawn from secondary sources. The first, from the automotive industry, shows how establishing circular economy processes may require new, dedicated facilities to be established, distinct from but connected to the existing forward, linear supply chain, and new network relationships to be configured, either with existing suppliers or with new ones who occupy emerging interstices of the developing circular economy. In other words, it shows the need for a major effort of technological and institutional reconfiguration across the wider network if service-based models are to be linked together to create a circular economy approach. The second, from the IT hardware industry, touches on similar structural issues, but also exemplifies the importance of sorting, qualification and valuation rules that have to be developed to make the circular flows function. These emerge endogenously through interactions within the network, as well as from external regulatory sources.

Car manufacturers Renault have developed circular economy approaches in various aspects of their business, and this has required the establishment of new facilities and the development of new practices and relationships with key suppliers. (This account is summarised from the World

Economic Forum report (WEF, 2014) and the Ellen Macarthur Foundation[1]). Renault has established a remanufacturing plant near Paris, where 325 people are employed to examine, test and recover mechanical subassemblies (e.g. water pumps). These remanufactured parts are then sold at 50-70% of their original price, with a one-year warranty, for use in cars already on the road. The relatively low prices may make it economical to repair a car that would otherwise be deemed a write-off, based on the cost of brand new spare parts: in this way, the restorative effect is amplified. This kind of remanufacturing has been made more feasible by modifying product designs with re-use and remanufacturing in mind at the outset. Such practices include greater use of standardised components, to make sorting and, hence, re-use easier, and changing material specifications where possible, so that materials recovered are maintained at a grade appropriate for the manufacture of new vehicles rather than being downgraded. This redesign work has been conducted in collaboration with recyclers and waste management companies. The Renault supply network has also been 'repurposed' and reconfigured. Recovery of sub-assemblies for repair and remanufacturing is incorporated into the return trips of delivery vehicles used to deliver replacement parts to dealers.

Our second case is a study of product recovery in the IT equipment industry by Insanic and Gadde (2014). The configuring and management of the reverse flows in a circular economy context is central to this case. Focussing on logistics firms who specialise in the recovery of IT equipment, Insanic and Gadde apply the concept of 'transvection' from early channels literature (Alderson, 1965) to the reverse flow of recovered items. The transvection approach draws attention to the alternating stages of transformation (collection, processing, transportation) and 'sorting'. The logistics firm is concerned to organise activities for economies of scale in transportation and processing. But Insanic and Gadde's study also reveals the critical role of the sorting rules that are applied at each sorting stage and by the various firms in the network. Products need to be tested for their condition and eventually disassembled, with their component parts being assigned to different recovery paths – some will be good enough to be reused, some will be repaired, some will be recycled and others will be disposed of. All these operations require important investments in socio-technical infrastructures, namely testing and diagnostic equipment, facilities for separating out materials and directing them to appropriate recovery paths (Insanic, 2014). In other words, products are qualified at these critical junctures in their biographies. Furthermore, Insanic and Gadde find that these sorting rules become manifest 'through the interaction among actors' (Insanic and Gadde, 2014: 276). In this way, the qualification criteria and the network are to some extent mutually constitutive.

[1] http://www.ellenmacarthurfoundation.org/circular-economy/interactive-diagram/the-circular-economy-applied-to-the-automotive-industry

4.4 'Smart, connected' products: the emerging potential of the internet of things (IoT)

The circular economy is co-evolving with the Internet of Things (IoT). This entails the widespread, internet-enabled connectivity between objects that generate and capture large quantities of data about their use, context and interaction with other objects and actors (Kortuem et al., 2010). Porter and Heppelman (2014) term these 'smart, connected products'. The IoT opens up the possibility of creating connected, rich biographies of products going down to specific parts and components that can be exploited in a variety of ways. Allmendinger and Lombreglia (2005:145) neatly summarised this argument: "A device that can report back to its maker on its status and usage represents the foundation for a much richer and longer-term customer relationship". At the most basic level, the availability of data can enable companies to better plan and deploy their service capabilities in routine maintenance, for example. A connected product may also open up business opportunities adjacent to maintenance – e.g. management of spare parts inventories. To some degree, this is already understood in the servitization literature (Grubic et al., 2011).

Moving beyond dyadic, buyer-supplier relationships, in the circular economy, the IoT can help to solve some of the critical qualification, classification and categorisation problems that stand in the way of achieving circular economy ideals, in settings where products circulate beyond the direct governance of one coordinating firm. For example, firms can explore opportunities for capacity utilisation of resources as when forward and reverse logistics loops can be made to overlap – e.g. IT firms can deliver new computer systems as well as collect disposed machines using the same logistics infrastructure (Insanic, 2014). Better knowledge of the state of products and their components allow firms to set up, by themselves or in collaboration with selected partners, network paths to deal with different recovery options (e.g. refurbish or dismantle and dispose). Firms may thus offer not just to sell or rent equipment but provide a broad range of services around the product, including maintenance, disposal and replacement of equipment. Results-oriented servitization models based on the circular economy notion will also allow for a change in how products themselves are designed (e.g. design for maintainability) as well as incentivizing firms to use refurbished parts, recycle materials and so on.

Smart, connected products not only enhance efforts to develop a circular economy but can also potentially allow different approaches to markets. A traditional marketing tool such as segmentation may be rethought along the lines of usage patterns rather than customer characteristics. As companies gather usage data, they can gain novel insights on usage patterns by customer, and configure offerings to different customers in much finer-grained fashion (Porter and Heppelmann, 2014). Kortuem et al.'s (2010) study of the use of smart objects to monitor usage of rental

equipment suggests the potential for the yield management of rental assets and fine-tuned pricing policies in line with actual usage, not just the rental period. Such approaches help achieve both business and sustainability objectives. This draws attention to potential business opportunities arising specifically from owning, controlling and integrating the data streams stemming from the development of the IoT. Product companies may find that the data they collect far exceeds their own requirements and might be useful to others. Data about a fleet of trucks, for example, might be useful to other fleet operators, insurance companies or road assistance companies (Porter and Heppelman, 2014). In other cases, firms need to develop strong data analytics, and actuarial as well as financial capabilities to absorb the risks that go with results-based servitization models (Iansiti and Lakhani, 2014). An important question here is who is best placed to develop and maintain the requisite capabilities to operate these business models. The widespread achievement of the circular economy depends in part on solving institutional problems around the ownership and use of data, as well as of products.

5. Beyond the circle – the generative potential of repair

The circular economy examples from the automotive and IT industries, although entailing the reconfiguration of supply networks and the development of new systems of qualification, are mostly concerned with relatively closed loops, and with the recovery and partial restoration of products within relatively narrow specifications. We now take a further step, exploring the implications of a wider conceptualisation of repair, emphasising its generative potential.

5.1 Re-thinking repair

Repair is typically mentioned as part of the range of possible product-related services in the servitization and solutions literatures. Sometimes repair becomes part of 'MRO' – maintenance, repair and overhaul (Ayeni et al., 2011; Wilkinson et al., 2009). PSSs that entail the retention of ownership of capital assets by their manufacturers and payment by the customer for access are supposed to incentivise manufacturers to design for improved ease of maintenance so as to reduce their own costs. As discussed, instrumentation can provide prognostic and diagnostic information to help in this (Grubic et al., 2011). Despite this central role for maintenance and repair, however, there is very little sustained reflection on the nature and role of repair in such systems. As well as requiring a wider scope of consideration, extending beyond the typical PSS dyad, the circular economy also can be seen to entail a potentially more profound and generative conceptualisation of repair. As such, we want to argue for a much richer notion of repair, one that encompasses a widespread,

creative, innovative and reconstituting capability and sensibility, rather than a narrowly-delineated process of restoring a given object to a certain specification in the context of a dyadic relationship between manufacturer and user.

One such perspective is provided by Graham and Thrift (2007). They argue that in some areas of the economy, notably those associated with vital infrastructures such as roads, water, electricity and telecommunications, the activity of repair is fundamental to the continuous reproduction of socio-technical order (Graham and Thrift, 2007), as well as a major source of employment. Despite this, among various commentators and analysts, there is a general pre-occupation with original manufacture, and repair and re-use are relatively unsung activities. Graham and Thrift argue that they could usefully take a more central role in our analysis:

> "...perhaps we have been looking in the wrong place. Perhaps we should have been looking at breakdown and failure as no longer atypical and therefore only worth addressing if they result in catastrophe and, instead, as breakdown and failure as the means by which societies learn and learn to re-produce." (Graham and Thrift, 2007: 5)

Various forms of repair, improvisation and systemic engagement with and between manufactured artefacts - cars, bridges, roads, buildings, computer networks and so forth – therefore constitute opportunities for learning, development and long-term value creation.

In some ways, this view is consistent with the circular economy argument: repair and its close companions must become normal and central concerns, not occasional and marginal ones. Similarly, servitization emphasises 'moving down the supply chain' to capture value from service activities such as repair. But Graham and Thrift's argument takes an additional step. Whereas the circular economy argument is principally concerned with the objective of sustainability, which is to be achieved by maintenance of or restoration to the *status quo*, Graham and Thrift suggest that repair is more than restoration – it is an opportunity for learning and innovation. Products or whole infrastructures can be repaired and upgraded to make them contemporary. They can be cannibalised for parts and materials recycled so that parts of objects live on in different systems. In this sense, products can have colourful biographies.

Maintenance of and restoration to the *status quo* also suggests a closed-loop chain of manufacture, supply, use, recovery, repair and re-supply. Indeed, representations of the circular economy like the one shown in Figure 1 tend to reinforce the 'closed loop' conception. Guide and van Wassenhove (2009: 10) define closed-loop supply chain management "…as the design, control, and operation of a system to maximize value creation over the entire life cycle of a product with dynamic recovery of

value from different types and volumes of returns over time". But this raises two separate issues regarding the feasibility of this approach: first, closing loops assumes that firms are able to keep close control of their linear supply chains, in the forward and reverse directions. As the case of Renault indicates, closing loops requires significant investments in redesigning products as well as recalibrating relationships with key suppliers. Secondly, the notion of extracting value from a product's life cycle implies that products are containers of value that can be successively unlocked as they circulate through pre-determined stages (e.g. use, recovery).

Taking a product biography perspective, however, allows us more readily to see beyond the closed-loop supply chain: if products are 'objects with a career', as with workers in contemporary society, products are likely to have multiple or portfolio careers. They are subject to "classifications and reclassifications in an uncertain world of categories whose importance shifts with every minor change in context" (Kopytoff, 1986: 90), processes that are intimately entangled with valuation. As Çalişkan and Callon (2009: 389) noted:

> "Nothing moves on its own. If a good is produced it is because it has a value for its producer; if it is distributed it is because it is a source of value for its distributor; and if it is consumed it is because it has a value in its consumer's eyes. The forces that explain the circulation-transformation of things are the same forces that give things value."

These valuation processes may determine that, say, a water-pump is no longer valued in such a way that it continues to have a career in the re-manufactured water-pump network. If so, it moves on to another career, being valued in new ways because of the incentives provided by material scarcity (this is termed 'cascaded use' in the circular economy policy literature (WEF, 2014: 15)); new network interactions give rise to the systems and technologies of qualification and the institutions in which they reside. In this way, exit from one circuit may not mean terminal breakdown, failure and disposal, but provide a site of innovation, learning and re-production.

5.2 The generativity of repair: the case of end-of-life ships

Such wider understandings of how products are valued and revalued as they are qualified and potentially attach themselves to new networks and chains are revealing. Scholars in human geography (e.g. Gregson et al., 2010; Hobson, in press) have been concerned for some time with the role of the relatively poor global south in dealing with the by-products of richer economies in the northern hemisphere. The relative poverty, cheaper labour and scarcer raw materials provide the means and incentives to engage in activities of repair that hitherto have not made economic sense in

the affluent north. One such example is the breaking of end-of-life ships on the beaches around Sitakunda in Bangladesh, studied by Gregson et al. (2010).

We use this example to illustrate parts of our argument for a product biography approach. It shows how open and extended circuits of recycling, re-manufacturing and re-purposing are created through gradual processes of qualification, valuation and institutionalisation, and how these processes of valuation interact with innovation in technology, organisation and markets. In servitization terms, it points to a much richer notion of what can take place in a 'repair', how valuation, innovation and organisation can be combined to create opportunities for novel value creation in a network, and suggests how the environmental and business rationales for servitization and circular economy approaches can converge.

The ship-breaking loop is far from closed: steel plate from the ships provides 90% of the steel used in Bangladesh; ship's chandlery is re-used by the country's fishing fleet; electric motors, compressors and ship's boilers are reconditioned and used in various land-based industries, notably the burgeoning Bangladeshi clothing export sector. It is claimed that 99% of a typical ship is 'recycled' (Gregson et al., 2010: 484). The seemingly chaotic, laborious and dangerous dismantling of large ships reminds us that although we are witnessing the destruction of the ship as a valued, integral object, the dying ship is also a composite of materials with their own values and further circulation potential. Instead of valuing ships solely as objects performing a function, we can now see ships for the value of materials and components that can be recovered, furniture that can be re-used or reprocessed, and so on.

Among these many elements that find other uses, Gregson *et al.* focus on the ships' furniture. Of particular interest here is how the furniture gradually came to be valued. Initially, it was seen as an obstacle to the recovery of the more obvious value in the thousands of tons of steel scrap that each ship comprises; poor people would scavenge leftover wooden materials from the breaking yard and sell them by the roadside, with ship breakers glad to have the burden taken off their hands. Subsequently, furniture retailers began more deliberately providing labour to remove furniture from the ships to sell 'as-is'; then, they began sending agents aboard the ships to participate in auctions arranged by the ship breakers. A network of workshops emerged, in which various forms of repair and re-working are carried out; similarly, a number of specialist furniture retail shops were established in the locality, selling specific identifiable genres of furniture particularly valued by the growing Bangladeshi middle classes. In a similar way, but perhaps less surprisingly, steel-re-rolling mills have been set up alongside the road just a few hundred metres from the ship-breaking yards. In

other words, the institutional and socio-technical infrastructure to enable the recovery, valuation and re-use of the materials from broken ships has gradually been constructed.

Such systems of recovery and re-use require new modes of qualification-valuation which are not restricted to linear supply chains, or to closed-loop ones. Rather, they mean finding ways to insert materials into economic circuits and frame them in novel ways. As Gregson et al. (2010: 853) comment:

> "Animating materials anew, rekindling them is curtailed not just by limits of the imagination, by knowledge or indeed by ways of seeing, it is framed too by the categories and classifications that surround stuff in particular parts of the world – particularly discarded objects declared to be 'end-of-life' – and by the markets that are available to goods fabricated from secondary materials."

These observations suggest a move away from linear value chains to multiple, enmeshed networks of circulation and exchange (Lepawsky and Mather, 2011), and re-conceptualising products as assemblages of materials that have been brought together and stabilised as particular forms, that will eventually stop working as a unit (Gregson et al., 2010) and move onto new chapters in their respective biographies.

6. Discussion

6.1 Conceptual implications of the product biography approach

Dismantled ships are rather different to the typical domain of the servitization debate, which has largely been focussed on simpler, dyadic settings. But they serve to point up in sharp relief the mutually constitutive nature of systems of qualification and valuation, and the networks of activities that they intersect with and embody. As Graham and Thrift have articulated, albeit perhaps with more prosaic examples in mind, repair can be a site of rejuvenation, creativity and entrepreneurial activity, as well as being a means for conserving and restoring the status quo.

In the examples we have identified and described, the entrepreneurial opportunities arise from the particular or singular (particular water pumps, computer terminals, or ship's furniture) being qualified, perhaps processed as a result of qualification, then re-qualified and re-commodified. Importantly, re-commodification makes it possible to value them. The product biography approach is rooted in precisely this alternation between the singular and the commodified.

Qualification requires the definition of categories and classification regimes. In Insanic and Gadde's (2014) study, this occurred through bottom-up, mutual adjustment of activities amongst private actors, to define sorting rules. But such regimes are also shaped by governments and supranational institutions (see also Plepys et al., 2015). Kama (2015) suggests the theory of the circular economy has been instrumental in establishing the EU's Waste Electronic and Electrical Equipment (2012/19/EU) or e-waste directive. Through this initiative, the EU has made the circulation of electronic products traceable and monitored within the territorial confines of the Union as well as making electronic waste a source of raw materials. This initiative aimed to create a market in which electronic waste can be classified, valued and traded, and in which material flows could be tracked and accounted for within a self-contained space. As Neyland and Simakova (2012) and Kama (2015) remark, determining what could be valuable to whom and in what circumstances did not prove easy. It turns out that e-waste is, as the WEF (2013) report would put it, still locked in the powerful grip of the technical, economic and legal logic of linear chains where value disappears with use or consumption.

The Internet of Things could allow the almost continuous tracking of the biography of individual products as they are attached to and detached from networks of other products and actors. This offers potentially much richer insights than established techniques of remote condition monitoring of major pieces of capital equipment (e.g. Grubic et al., 2011): as it becomes possible to make even relatively inexpensive products 'smart', and data capture and analysis capabilities and capacity develop, the interaction of multiple product biographies can be understood with greater granularity. Furthermore, the IoT can play a major role in enabling the qualification and other institutional structures and processes that are required to make the circular economy a reality.

6.2 What the circular economy reveals

The circular economy has served primarily as a challenging conceptual and empirical context in which to explore the possible implications of the product biography approach, released from the constraints of conventional framings of servitization, rather than as our target application domain. The economically-inspired notion of servitization and the ecologically-inspired circular economy share common precursors; as such, they have comprised similar shifts in relationships and practices, but with different primary aims. However, now that sustainability is becoming a much more mainstream corporate concern, the aims as well as the practices are converging rapidly. In this way, we therefore contend, service-led growth in product firms must be rooted in this understanding of a much fuller notion of the product's biography, the various touch points, episodes, qualifications and repairings that it may undergo, and the way that these are all mutually constituted with the

networks to which products are attached. This is for both business reasons and sustainability reasons, which are increasingly one and the same thing.

Many forms of servitization see customers unwilling to own 'products', preferring to pay for access to them; in the circular economy, ownership, if contemplated at all by customers, is seen even more as a temporary state of affairs: customers own products in the expectation and anticipation that they will eventually return them, upgrade them, have them repaired, share them, sell them on, part-exchange them, and so on. In this context, products are the basis for service-led growth precisely because of the various forms of *instability* that we have identified, rather than being the basis for service-led growth because of their stability, as the marketing and servitization literatures might suggest. As we have previously argued (Araujo and Spring, 2006), what have been termed products and services are both institutional achievements: to be traded, at least, both have to be qualified and temporarily stabilised as goods – the corollary of this is that instability is the norm, not the exception. Likewise within firms, qualification is necessary to make products and services into manageable objects (Czarniawska and Mouritsen, 2009). Institutionally, there is both continuity and change through the product biography: a product may change physically a great deal and yet retain its identity according to systems of registration; on the other hand, products are frequently re-qualified and redefined in the network as they attach themselves to and detach themselves from actors and other artefacts – a truck used by a logistics firm under a 'servitized' access-based contract is defined by each use by a different driver, journey on a particular route, etc. The product is formed and redefined by each episode of service in which it is implicated, rather than the service being delivered on the stable 'platform' or 'vehicle' of the product.

6.3 Implications for servitization

The insights arising from our analysis have potential impact on several areas of servitization literature. In particular, they can inform the emerging debate on multiplicities of possible service transitions. Recent studies have argued that, rather than unidirectional shifts along a simple product-service continuum (Evanschitzky et al., 2011) various alternative types of transition may be appropriate. For example, Kowalkowski et al. (2015) propose availability provider, performance provider and industrialiser as three possible strategies. While we suggest that a product biography perspective can always be useful in drawing attention to the contextual and institutional stabilisation of products, it is perhaps in the performance provider model that the seeking out of entrepreneurial opportunities at moments of transition and instability is most appropriate, and most feasible. Given the typically close relationships between manufacturer and customer, opportunities to monitor and identify transitions are most evident in these cases.

Of course, the product biography and circular economy approaches encourage perspectives that extend beyond the manufacturer-customer dyad. Storbacka et al. (2013), also concerned with identifying multiple possible trajectories for the development of what they call 'solution business models', see organizational 'networkedness' as a critical parameter. Indeed, an emerging theme in the servitization and solutions literature is the critical role of the wider network, for example in providing complementary capabilities (Gebauer et al., 2013; Eloranta and Turunen, in press), in co-creating and, indeed, in understanding value (Jaakkola and Hakanen, 2013; Macdonald et al., 2011). More specifically still, engagement with an extended network including customers' customers has recently been seen as important in incorporating sustainability more centrally into business value propositions (Lacoste, 2016). Extended product biographies, and most circular economy practices, require this interdependence between multiple network actors to bring about necessary qualifications of products and the coordination of product flows and processes of repair, remanufacturing and so forth. A product biography and qualification perspective draws attention to the distributed capabilities and localised and temporally-specific delineation and creation of value at moments of product instability, in contrast to established notions of products embodying the manufacturer's capabilities and following pre-determined and standard life-cycles.

The particular contours of the product's biography also depends on the basic structural role of a product in a supply network: Storbacka et al. (2013) distinguish between 'installed base' and 'input-to-process' contexts. Clearly, the product biography of a machine tool is very different to that of a unit of raw material such as a sheet of steel which is 'transformed during the customer's process in such a way that it ceases to exist as a separate entity' (Storbacka et al., 2013: 706). As the requirement to qualify such materials in a circular economy network increases, however, working out how to track the (shifting and multiplying) biography of products of this type, as well as 'installed base' products, will become an increasingly important challenge, and a potential business opportunity. Firms and circular economy networks that can guarantee the provenance of materials and components in reverse cycles of re-use, re-manufacturing and recycling will gain a competitive advantage over those who are less able to understand the biographies of the products that flow within them.

There are also internal management implications for firms. As sustainability and circular economy thinking become more mainstream, and the potential of 'smart connected products' to provide the basis for data-enabled service offerings is realised, product firms may need to think again about who manages the combination of sustainability initiatives, product manufacture, service process delivery, and data capture and use. One possibility is an enhanced role for key account management (KAM),

which, it has recently been argued, is important in integrating knowledge in solutions businesses (Hakanen, 2014). A product biography perspective can be used as a guiding framework to sensitize KAM to the critical sites and moments of product transition and entrepreneurial opportunity. A similar logic can be applied to the development of the sales force more generally in servitization contexts (Ulaga and Loveland, 2014).

7. Conclusions

This paper has made a number of contributions to the servitization literature. Whereas the extant literature regards product-centric firms gradually and sometimes tentatively, moving into services, we contend that this move requires more, rather than less attention should be paid to products. The notion of products that pervades much of the servitization literature is either too narrow or poorly developed.

Our first contribution is thus to conceive of products as stabilised assemblages of materials often with complex biographies that undergo multiple qualifications and valuations through their useful lives. Each qualification point provides opportunities for turning products into goods (e.g. second hand cars) or for associating services with a product (e.g. maintenance). As we have argued, products are not stable entities acting as gateways to service income streams. Rather, changes in products (e.g. their status or condition) create entrepreneurial opportunities for service value-creation that go well beyond restoring products to their original status (e.g. turning repair activities into opportunities for improved performance).

Our second contribution, based on the notion of the circular economy, suggests that products' biographies should be seen as a composite of trajectories rather than following a linear path from design to manufacture and disposal. Products get repaired, refurbished, upgraded, tinkered with, dismantled, reassembled and discarded. Their enduring integrity should not blind us to the changes that many products undergo during their often long lives. We have pushed these arguments further by showing how the reverse loops of the circular economy offer further opportunities for entrepreneurial service creation. Whereas the literature on PSS highlighted the incentives for dematerialisation, and closed loop supply chains focused on opportunities for remanufacturing, we have argued that a circular economy perspective often requires the creation of novel network relationships involved in multiple activities such as reverse logistics, the dismantling of products, the classification and sorting of product components, the recycling of materials and so on. In short, the relationship between servitization and sustainability suggested by the circular economy goes far

beyond what is implied from a producer-centric approach with its narrow focus on incentives for dematerialisation, and repair and maintenance as restorative functions. From a circular economy vantage point, the entrepreneurial opportunities for services connected to products are much larger than those implied by the servitization and encompass reverse as well as forward supply chains. In connection with this, we have argued that the 'smart, connected products' of the IoT permit the elaboration of systematic and comprehensive product biographies. Whereas exemplar cases of servitization built around capital goods already rely on dedicated systems for data gathering and analysis on product performances, the IoT promises to extend this scenario to a much wider range of products and markets, making new forms of service business model possible, as well as underpinning a shift to a truly circular economy.

Finally, we have identified more specific implications for servitization. The product biography perspective can inform the development of multiple service transition models and pathways in product firms, giving further structure to the emerging argument that service transition is not a unidirectional move along one axis. Product biographies stress the extension beyond the producer-customer dyad and the role of extended systems of classification and qualification among multiple actors. This provides an institutional underpinning to recent discussions of the importance of the wider network in servitization in general, and in sustainable service-based business models in particular. Furthermore, we suggest that KAM and even sales roles need to play a new role in integrating the extended, sustainability-infused approach that the product biography and circular economy approaches entail.

Seeing product biographies from the wider prism of the circular economy points to novel research directions for the servitization literature. First, it suggests a move away from producer-centric business models and to the wider network of actors and entrepreneurial opportunities surrounding product biographies, from design to material recovery options. Secondly, the idea of the circular economy provides the opportunity to articulate a clearer link between servitization and environmental sustainability, beyond notions of incentives to dematerialisation or designing products with lower servicing costs. From a circular economy perspective, servitization only contributes to environmental sustainability to the extent that it fill gaps around the institutional structures that enable loops to be closed around products and their constituent materials throughout their useful lives.

References

Akerlof, G.A. (1970) The Market for "Lemons" - Quality Uncertainty and the Market Mechanism. *Quarterly Journal of Economics,* 84, 3**,** 488-500.

Alderson, W. (1965) *Dynamic marketing behavior: A functionalist theory of marketing*, RD Irwin Homewood.

Allmendinger, G. and Lombreglia, R. (2005) Four strategies for the age of smart services. *Harvard Business Review,* 83, 10**,** 131.

Araujo, L. and Spring, M. (2006) Services, products, and the institutional structure of production. *Industrial Marketing Management,* 35, 7**,** 797-805.

Ayeni, P., Baines, T.S., Lightfoot, H. and Ball, P. (2011) State-of-the-art of'Lean'in the aviation maintenance, repair, and overhaul industry. *Proceedings of the Institution of Mechanical Engineers, Part B: journal of engineering manufacture***,** 0954405411407122.

Baines, T., Lightfoot, H., Peppard, J., Johnson, M., Tiwari, A., Shehab, E. and Swink, M. (2009) Towards an operations strategy for product-centric servitization. *International Journal of Operations & Production Management,* 29, 5**,** 494-519.

Baines, T.S., Lightfoot, H.W., Evans, S., Neely, A., Greenough, R., Peppard, J., Roy, R., Shehab, E., Braganza, A., Tiwari, A., Alcock, J.R., Angus, J.P., Bastl, M., Cousens, A., Irving, P., Johnson, M., Kingston, J., Lockett, H., Martinez, V., Michele, P., Tranfield, D., Walton, I.M. and Wilson, H. (2007) State-of-the-art in product-service systems. *Proceedings of the Institution of Mechanical Engineers Part B-Journal of Engineering Manufacture,* 221, 10**,** 1543-1552.

Baldwin, C. and Clark, K.B. (1997) Managing in an age of modularity. *Harvard Business Review,* Sept/Oct**,** 84-93.

Çalişkan, K. and Callon, M. (2009) Economization, part 1: shifting attention from the economy towards processes of economization. *Economy and Society,* 38, 3**,** 369-398.

Callon, M., Meadel, C. and Rabeharisoa, V. (2002) The economy of qualities. *Economy and Society,* 31, 2**,** 194-217.

Carter, C.R. and Easton, P.L. (2011) Sustainable supply chain management: evolution and future directions. *International Journal of Physical Distribution & Logistics Management,* 41, 1**,** 46-62.

Corey, E.R. (1975) Key options in market selection and product planning. *Harvard Business Review,* Sep-Oct**,** 119-128.

Crang, M., Hughes, A., Gregson, N., Norris, L. and Ahamed, F. (2013) Rethinking governance and value in commodity chains through global recycling networks. *Transactions of the Institute of British Geographers,* 38, 1**,** 12-24.

Czarniawska, B. and Mouritsen, J. (2009) What is the object of management?: how management technologies help to create manageable objects. IN Chapman, C. S., Cooper, D. J. & Miller, P. B. (Eds.) *Accounting, Organizations, and Institutions: Essays in Honour of Anthony Hopwood.* Oxford, Oxford University Press. 157-174

Davies, A. (2004) Moving base into high-value integrated solutions: a value stream approach. *Industrial and Corporate Change,* 13, 5**,** 727-756.

Eggert, A., Hogreve, J., Ulaga, W. and Muenkhoff, E. (2014) Revenue and Profit Implications of Industrial Service Strategies. *Journal of Service Research,* 17, 1**,** 23-39.

Ellen Macarthur Foundation (2015) About the Ellen MacArthur Foundation http://www.ellenmacarthurfoundation.org/ 12th April

Eloranta, V. and Turunen, T. (in press) Platforms in service-driven manufacturing: Leveraging complexity by connecting, sharing, and integrating. *Industrial Marketing Management*.

Epp, A.M. and Price, L.L. (2010) The storied life of singularized objects: Forces of agency and network transformation. *Journal of Consumer Research,* 36, 5**,** 820-837.

Evanschitzky, H., Wangenheim, F.V. and Woisetschläger, D.M. (2011) Service & solution innovation: Overview and research agenda. *Industrial Marketing Management,* 40, 5**,** 657-660.

Fang, E., Palmatier, R.W. and Steenkamp, J.-B.E.M. (2008) Effect of Service Transition Strategies on Firm Value. *Journal of Marketing,* 72, 5**,** 1-14.

Galbraith, J.R. (2002) Organizing to deliver solutions. *Organizational Dynamics,* 31, 2**,** 194-207.

Gebauer, H., Edvardsson, B., Gustafsson, A. and Witell, L. (2010) Match or mismatch: strategy-structure configurations in the service business of manufacturing companies. *Journal of Service Research,* 13, 2**,** 198-215.

Gebauer, H., Paiola, M. and Saccani, N. (2013) Characterizing service networks for moving from products to solutions. *Industrial Marketing Management,* 42, 1**,** 31-46.

Golicic, S.L. and Smith, C.D. (2013) A Meta-Analysis of Environmentally Sustainable Supply Chain Management Practices and Firm Performance. *Journal of Supply Chain Management,* 49, 2**,** TBA.

Graham, S. and Thrift, N. (2007) Out of order: understanding repair and maintenance. *Theory, Culture & Society,* 24, 3**,** 1-25.

Gregson, N., Crang, M., Ahamed, F., Akhter, N. and Ferdous, R. (2010) Following things of rubbish value: End-of-life ships,'chock-chocky' furniture and the Bangladeshi middle class consumer. *Geoforum,* 41, 6**,** 846-854.

GrÖnroos, C. (1998) Marketing services: the case of a missing product. *Journal of Business & Industrial Marketing,* 13, 4/5**,** 322-338.

Grubic, T., Redding, L., Baines, T. and Julien, D. (2011) The adoption and use of diagnostic and prognostic technology within UK-based manufacturers. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture,* 225, 8**,** 1457-1470.

Guide, V.D.R. and Van Wassenhove, L.N. (2009) OR FORUM-the evolution of closed-loop supply chain research. *Operations Research,* 57, 1**,** 10-18.

Hakanen, T. (2014) Co-creating integrated solutions within business networks: The KAM team as knowledge integrator. *Industrial Marketing Management,* 43, 7**,** 1195-1203.

Harman, G. (2010) Technology, objects and things in Heidegger. *Cambridge Journal Of Economics,* 34, 1**,** 17-25.

Hobson, K. (in press) Closing the loop or squaring the circle? Locating generative spaces for the circular economy. *Progress in Human Geography*.

Insanic, I. (2014) Product Recovery in Business Networks: An Inter-Organisational Approach. *Department of Technology Management and Economics.* Gothenburg, Sweden, Chalmers University of Technology, .

Insanic, I. and Gadde, L.-E. (2014) Organizing product recovery in industrial networks. *International Journal of Physical Distribution & Logistics Management,* 44, 4**,** 260-282.

Jaakkola, E. and Hakanen, T. (2013) Value co-creation in solution networks. *Industrial Marketing Management,* 42, 1**,** 47-58.

Kama, K. (2015) Circling the economy: resource-making and marketization in EU electronic waste policy. *Area,* 47, 1**,** 16-23.

Kim, S.-H., Cohen, M.A. and Netessine, S. (2007) Performance contracting in after-sales service supply chains. *Management Science,* 53, 12**,** 1843-1858.

Kindström, D. and Kowalkowski, C. (2014) Service innovation in product-centric firms: a multidimensional business model perspective. *Journal of Business & Industrial Marketing,* 29, 2**,** 96-111.

Kopytoff, I. (1986) The cultural biography of things: commoditization as process. IN Appadurai, A. (Ed.) *The social life of things: Commodities in cultural perspective.* Cambridge, Cambridge University Press. 64-92

Kortuem, G., Kawsar, F., Fitton, D. and Sundramoorthy, V. (2010) Smart objects as building blocks for the Internet of things. *Internet Computing, IEEE,* 14**,** 44-51.

Kotler, P. (1967) *Marketing management: analysis, planning and control,* Englewood Cliffs, NJ, Prentice-Hall.

Kotler, P. (1980) *Marketing Management: Analysis, Planning and Control,* Englewood Cliffs, NJ, Prentice-Hall.
Kowalkowski, C., Windahl, C., Kindström, D. and Gebauer, H. (2015) What service transition? Rethinking established assumptions about manufacturers' service-led growth strategies. *Industrial Marketing Management,* 45**,** 59-69.
Lacoste, S. (2016) Sustainable value co-creation in business networks. *Industrial Marketing Management,* 52**,** 151-162.
Lay, G., Schroeter, M. and Biege, S. (2009) Service-based business concepts: A typology for business-to-business markets. *European Management Journal,* 27, 6**,** 442-455.
Lepawsky, J. and Mather, C. (2011) From beginnings and endings to boundaries and edges: rethinking circulation and exchange through electronic waste. *Area,* 43, 3**,** 242-249.
Locke, J. and Lowe, A. (2007) A Biography: Fabrications in the Life of an ERP Package. *Organization,* 14, 6**,** 793-814.
Macdonald, E.K., Wilson, H., Martinez, V. and Toossi, A. (2011) Assessing value-in-use: A conceptual framework and exploratory study. *Industrial Marketing Management,* 40, 5**,** 671-682.
Mathieu, V. (2001) Service strategies within the manufacturing sector: benefits, costs and partnership. *International Journal of Service Industry Management,* 12, 5**,** 451-475.
Matthyssens, P. and Vandenbempt, K. (2008) Moving from basic offerings to value-added solutions: Strategies, barriers and alignment. *Industrial Marketing Management,* 37, 3**,** 316-328.
Matthyssens, P. and Vandenbempt, K. (2010) Service addition as business market strategy: identification of transition trajectories. *Journal of Service Management,* 21, 5**,** 693-714.
Michel, S., Vargo, S.L. and Lusch, R.F. (2008) Reconfiguration of the conceptual landscape: a tribute to the service logic of Richard Normann. *Journal of the Academy of Marketing Science,* 36, 1**,** 152-155.
Mont, O. (2002) Clarifying the concept of product-service system. *Journal of Cleaner Production,* 10**,** 237-245.
Mont, O. (2004) Institutionalisation of sustainable consumption patterns based on shared use. *Ecological Economics,* 50, 1-2**,** 135-153.
Mulgan, G. (2013) *The locust and the bee: predators and creators in capitalism's future,* Princeton NJ, Princeton University Press.
Neely, A. (2008) Exploring the financial consequences of the servitization of manufacturing *Operations Management Research,* 1, 2**,** 103-118.
Neyland, D. and Simakova, E. (2012) Managing electronic waste: a study of market failure. *New Technology, Work and Employment,* 27, 1**,** 36-51.
Nguyen, H., Stuchtey, M. and Zils, M. (2014) Remaking the industrial economy. *McKinsey Quarterly*.
Nordin, F. and Kowalkowski, C. (2010) Solutions offerings: a critical review and reconceptualisation. *Journal of Service Management,* 21, 4**,** 441-459.
Normann, R. (2001) *Reframing business: when the map changes the landscape,* Chichester, John Wiley.
Oliva, R., Gebauer, H. and Brann, J.M. (2012) Separate or Integrate? Assessing the Impact of Separation Between Product and Service Business on Service Performance in Product Manufacturing Firms. *Journal of Business-to-Business Marketing,* 19, 4**,** 309-334.
Oliva, R. and Kallenberg, R. (2003) Managing the transition from products to services. *International Journal of Service Industry Management,* 14, 2**,** 160-172.
Pine, B.J. (1993) *Mass Customization,* Boston, MA, HBS Press.
Plepys, A., Heiskanen, E. and Mont, O. (2015) European policy approaches to promote servicizing. *Journal of Cleaner Production,* 97**,** 117-123.
Pollock, N. and Cornford, J. (2004) ERP systems and the university as a "unique" organisation. *Information technology & people,* 17, 1**,** 31-52.
Porter, M.E. and Heppelmann, J.E. (2014) How smart, connected products are transforming competition. *Harvard Business Review,* 92, 11**,** 64-88.

Potts, G.W. (1988) Exploit your product's service life-cycle. *Harvard Business Review,* 66, 5**,** 32-36.
Prencipe, A., Davies, A. and Hobday, M. (2003) *The business of systems integration*, Oxford University Press.
Rabetino, R., Kohtamäki, M., Lehtonen, H. and Kostama, H. (2015) Developing the concept of life-cycle service offering. 49**,** 53-66.
Raddats, C. and Burton, J. (2011) Strategy and structure configurations for services within product-centric businesses. *Journal of Service Management,* 22, 4**,** 522-539.
Riddle, D.I. (1986) *Service-led growth: the role of the service sector in world development*, Praeger Publishers.
Salvador, F. (2007) Toward a product system modularity construct: literature review and reconceptualization. *IEEE Transactions on Engineering Management,* 54, 2**,** 219-240.
Sanchez, R. and Mahoney, J.T. (1996) Modularity, flexibility, and knowledge management in product and organization design. *Strategic Management Journal,* 17**,** Winter special issue 63-76.
Selviaridis, K. and Norrman, A. (2014) Performance-based contracting in service supply chains: A service provider risk perspective. *Supply Chain Management: An International Journal,* 19, 2**,** TBA.
Snir, E. (2001) Liability as a catalyst for product stewardship. *Production and Operations Management,* 10, 2**,** 190-206.
Spring, M. (2013) *Which business models might ensure UK value from emerging sectors? - Evidence paper 33 for the Foresight study The Future of Manufacturing: a new era of opportunity and challenge for the UK*, The Government Office for Science,
Spring, M. and Araujo, L. (2013) Beyond the service factory: service innovation in manufacturing supply networks. *Industrial Marketing Management,* 42, 1**,** 59-70.
Stahel, W. and Reday, G. (1976/1981) *Jobs for Tomorrow: The Potential for Substituting Manpower for Energy*, Commission of the European Communities,
Storbacka, K., Windahl, C., Nenonen, S. and Salonen, A. (2013) Solution business models: Transformation along four continua. *Industrial Marketing Management,* 42, 5**,** 705-716.
Stoughton, M. and Votta, T. (2003) Implementing service-based chemical procurement: lessons and results. *Journal of Cleaner Production,* 11**,** 839-849.
Tukker, A. (2004) Eight types of product-service system: eight ways to sustainability? Experiences from SusProNet. *Business strategy and the environment,* 13, 4**,** 246-260.
Ulaga, W. and Loveland, J.M. (2014) Transitioning from product to service-led growth in manufacturing firms: Emergent challenges in selecting and managing the industrial sales force. *Industrial Marketing Management,* 43, 1**,** 113-125.
Ulaga, W. and Reinartz, W.J. (2011) Hybrid offerings: how manufacturing firms combine goods and services successfully. *Journal of Marketing,* 75, 6**,** 5-23.
Vandermerwe, S. and Rada, J. (1988) Servitization of business: Adding value by adding services. *European Management Journal,* 6, 4**,** 314-324.
Vargo, S.L. and Lusch, R.F. (2004) Evolving to a new dominant logic for marketing. *Journal of Marketing,* 68, 1**,** 1-17.
Visnjic-Kastalli, I. and Van Looy, B. (2013) Servitization: Disentangling the impact of service business model innovation on manufacturing firm performance. *Journal of Operations Management,* 31, 4**,** 169-180.
WEF (2014) *Towards the circular economy: accelerating the scale-up across global supply chains* World Economic Forum,
Wilkinson, A., Dainty, A., Neely, A., Johnstone, S., Dainty, A. and Wilkinson, A. (2009) Integrating products and services through life: an aerospace experience. *International Journal of Operations & Production Management,* 29, 5**,** 520-538.
Windahl, C. and Lakemond, N. (2010) Integrated solutions from a service-centered perspective: Applicability and limitations in the capital goods industry. *Industrial Marketing Management,* 39, 8**,** 1278-1290.

Wise, R. and Baumgartner, P. (1999) Go downstream - The new profit imperative in manufacturing. *Harvard Business Review,* 77, 5**,** 133-141.

Yuan, Z., Bi, J. and Moriguichi, Y. (2006) The Circular Economy: A New Development Strategy in China. *Journal of Industrial Ecology,* 10, 1-2**,** 4-8.