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A THEORY OF SERVICES IN PRODUCTS INDUSTRIES

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A Theory of Services in Product Industries

Abstract

Even though services have become increasingly important for firms in many product industries, there lacks theory to explain under what conditions services should be important to product firms. We propose that services embody the product and market-related knowledge that transfer between the producer and customer in activities associated with selling, financing, using, maintaining, and repairing products. Building on the knowledge management and innovation literatures, we propose that the level and type of services provided within a product industry are associated with uncertainty, complexity, and competitive dynamics. Finally, we explore the implications for research in resource capabilities, industry verticalization, and technological change.

Keywords: services, strategy, product design, lifecycle, knowledge transfer

In many product-oriented industries, services have become increasingly important. In the case of automobiles, General Motors, Ford, and many other automakers generate the vast majority of their profits from a service activity closely tied to their product offerings – loans and leasing. The automobile industry overall generates a large portion of its profits not only from financing but from other product-related service activities such as insurance and repairs (Gadiesh & Gilbert, 1998). In the case of software products, companies often begin by emphasizing packaged product sales but, as the industry has matured, many now derive more revenues from maintenance (product patches, product updates, and routine technical support) and other types of services (such as consulting, product customization, and training) rather than from new product sales. Other technology product firms, such as IBM, Cisco, Hewlett-Packard, Sun Microsystems, Dell, and EMC, have also seen large increases in maintenance and other services as a percentage of their total revenues as their product lines mature. IBM, arguably the best-known example of this, targeted services under CEO Lou Gerstner and as a consequence saw this part of its business rise from 23 percent of revenues in 1992 to 52 percent in 2005 (Cusumano, 2004, 2008).

Despite the seeming importance of services, however, there is not much theory to help researchers or practitioners explain the conditions under which services matter in product industries. One prominent explanation of industry evolution, industry lifecycle theory (Abernathy & Utterback, 1978; Anderson & Tushman, 1990; Gort & Klepper, 1982; Klepper, 1996, 1997), is notably silent on the role of services. And, much of the early work on services was descriptive, simply documenting their rise by highlighting the increasing importance of "pure" service industries such as financial services and retail in the economy and spelling out the differences between managing product and service firms (e.g. Heskett, 1986). More recent work has studied how manufacturing firms can successfully organize and structure themselves to explore and exploit service opportunities as sources of revenue and profits (Davies, 2004; Oliva & Kallenberg, 2003; Wise & Baumgartner, 1999). The general view that emerges from the services literature is that services tend to become important for manufacturing firms once their industries reach a mature stage (Oliva & Kallenberg, 2003; Potts, 1988). Similarly, in the innovation literature, even though services are recognized to play an important role in the adoption of an innovation, it is believed that complementary assets such as services "do not loom large" (Teece, 1986, p. 251) until after the paradigmatic design emerges and industry dynamics shift toward cost-based competition.

Despite these predictions, there are many cases in which services "loom large" early in the lifecycle of an industry. For example, in the computer industry, consulting services to help firms determine their needs for a computer and implement the computer were very important to its early adoption (Campbell-Kelly, 2003). And in the automobile industry, historians are increasingly recognizing the importance of service and repair stations to its early technological progress (Franz, 2005). In short, even though industry cycles clearly influence the level of services within an industry, they are not the only factor.

In this article, we provide a more comprehensive theoretical perspective that can better explain the role of services in product industries. Unlike much of the previous research in services that has been mainly concerned with the question of "what" (i.e. describing the rise of services), we focus on answering the "how," "when" and "why"

(Bacharach, 1989) of the emergence of services and their implications for company performance. For example, what conditions prompt the emergence of services in a product industry? What happens when those conditions change? Do all services respond to the same dynamics? Does the importance of services in an industry change over time? Which types of companies are more likely to provide services in a product industry?

Part of the problem is that the concept of "services" within a product industry remains elusive. Many accounts implicitly follow Teece's classification of a services capability as a complementary asset, but presume that products must be established to a degree before services play a role. However, research has shown that the complementarity can flow from services to products, e.g., producers learn how customers actually use a product and this leads to technological changes (Rosenberg, 1983). Rather than define services strictly as they relate to products, we focus on the characteristics of the various kinds of service activities performed within an industry, for example, consulting, customization, installation, technical support, maintenance, repair, and training. Based on this perspective, we can think of many services as the transfer of knowledge about products and their use between producers and customers. Recognizing the role of knowledge in services allows us to draw from various well-developed literatures on knowledge acquisition and technical design to help determine under what conditions we would expect to see a rise in different types of services offered by product companies within traditionally product-oriented industries. Specifically, we relate the level and type of services we would expect to see in an industry to the level of technological and market uncertainty and complexity.

After establishing these fundamental relationships, we address services dynamically. Industry lifecycle theory is particularly useful to address these dynamic issues because it considers industry competitive effects as well as introduces the notion of a shift in competitive dynamics. A priori, a given type and level of services need not persist throughout the lifecycle of a product industry. Within different competitive dynamics, firms may invest in (and the market may demand) different kinds of services because the nature of services evolves in an industry in tandem with the evolution of the technology and customer requirements. To the extent that a product industry exhibits competitive dynamics that follow observed lifecycle patterns, our theory identifies the conditions that make different types of services potentially more important under these different competitive dynamics. Consequently, our theory can explain why, for instance, some industries tend to have an important service component from very early on (e.g., the first plain paper copiers, as well as mainframe computers and medical scanners) while others do not. Finally, we elaborate on the type of firms that are best positioned to provide those services: Companies that are the product producers themselves, or third parties that do not make the industry's physical products but exist in a related "ecosystem." In order to illustrate our ideas and propositions, throughout the discussion we consistently use examples such as the computer mainframe and the automobile, as well as some illustrations from other industries.

SERVICES IN PRODUCT INDUSTRIES

We are interested in the role of services in product-oriented industries. A starting point to define services in this context is to consider its definition within "pure" services industries, such as banking and education. Traditionally, the service industry literature defines the output of these industries as anything that is not a tangible, manufactured good (Bell, 1973; Berry, 1980; Mansharamani, 2007). This simple definition needs to be expanded for the case of services in product industries, where services are necessarily defined by their relationship to specific products. In early work along these lines, some scholars have defined services as an asset that complements products (Milgrom & Roberts, 1990; Teece, 1986). But even this definition needs to be expanded to cover the full breadth of the relationship between products and services. In particular, the "services as complementary assets" definition implicitly assumes that services follow a product and not vice-versa. However, there are instances in which services do not act as complements but as substitutes or precursors to products. For example, recall the early "application service provider" phenomenon within the computer industry during the 1980s. Firms would host the computer and application software and provide them as a service to customers, charging monthly rental fees rather than large, up-front product fees. This concept of "software as a service" has become even more popular in recent years (Dubey & Wagle, 2007). In other cases, such as in the information technology business, consulting firms may first provide services such as to determine customer needs, and then recommend product vendors.

It follows that, in addition to their direct relationship with a given product, services in product-oriented industries often include the bundling of products with the service offering. For example, repair work of automobiles or computer hardware often requires using spare or replacement parts. Even implementation of complex computer systems often involves the transfer of knowledge in the form of technical books and manuals. However, using tangible products while delivering an intangible service – such as using replacement components in repair work – is clearly different from the process of creating the tangible components, hence we view the repair work or consulting as distinctly separate service activities.

Given our focus in this paper and the corresponding scope conditions, we think of services in the case of product industries as activities that generally: (a) can be sold or given away separately from the industry's "physical" products; (b) relate directly to the industry's products and may even be necessary to use those products, but; (c) are not part of the production process of the physical goods themselves.[1] These activities often involve selling, financing, installing, and repairing the product and may occur before, during, or after the purchase of the industry's product. For instance, a customer may require consulting services before a product purchase in order to choose among product alternatives, taking into consideration the customers' legacy technology, organizational structure, and culture. Services may also occur during the purchase of the product, such as when customers obtain financial services (e.g., a loan or lease) in order to purchase an expensive product like a computer or an automobile. Finally, services can also occur after a product has been purchased. Examples of this latter type of services are installation, maintenance, repair, and training.

[1] These scope conditions are necessary to eliminate cases in which a product industry diversifies into a service industry, e.g, a steel firm purchasing an insurance company (such as US Steel in the 1980s), or a consumer electronics firm purchasing a bank (such as Sony in the 1990s).

A common characteristic of these different activities is that they entail transfer of product and market knowledge between the product firms and customers. For example, consulting services before and after the purchase of the product informs customers about the capabilities of the product and the best ways to take advantage of it. Even financing conveys some information about market conditions. Consider what lease or warranty terms convey about how the customer should use the product. Knowledge transfer goes both ways. Through the maintenance and repair operations, product firms may learn about the flaws of a particular technology design. Rosenberg (1983), for instance, cites the importance of service work in identifying issues such as metal fatigue that led to technological changes in the airplane manufacturing industry. Therefore, just as scholars describe products in terms of embodying the knowledge about component parts and design (Henderson & Clark, 1990; Nelson & Winter, 1982), we can think of services as embodying the product and market-related knowledge that is exchanged between the producer and the customer. Each of these different activities in selling, financing, and servicing exchanges different kinds of information and consequently generates different kinds of knowledge.

Within each kind of service there is a type of service, defined by its level of standardization. The technology literature is beginning to explain how a product's component parts and interfaces can evolve from being highly-customized to more standardized (Baldwin & Clark, 2000). Similarly, we can think of services existing along the customization and standardization continuum, where a customized service is an activity that is specific to a particular product-customer exchange and a standardized service an activity that generally applies to a wide-class of product-customer exchanges

(Mansharamani, 2007; Sundbo, 1997). For example, consider the differences between taking a car to a repair shop to get customized work done versus going to an oil change shop that performs the same kind of service regardless of the make and model. Or, consider an extensive training program done by a software vendor at a particular customer cite that teaches employees how to use a new custom-built application, as opposed to a software vendor that offers open-enrollment classes on how to use its new general-purpose application or operating system.

Finally, by defining services generally in terms of the knowledge transfer that underlies each activity, we can begin to identify the conditions under which the levels of this knowledge should increase. The technology innovation literature has usually related product knowledge to the levels of uncertainty and complexity; therefore, we will begin by considering how services relate to these characteristics. Traditionally, the innovation literature has thought of uncertainty and complexity primarily from the producer's perspective, but the literature is increasingly recognizing the customer perspective of purchasing and using the technology as an integral part of these concepts (Adner & Levinthal, 2001; Kahl, 2007; Leonard-Barton, 1988; Rosenberg, 1983). Defining services in terms of the knowledge transfer between producers and customers enables a clearer delineation between technical-related and use-related characteristics of uncertainty and complexity. Given that there are different kinds of services as well as types within each kind, we will also specify the relationships at these levels.

SERVICES AND UNCERTAINTY

Scholars have long acknowledged the pervasiveness of different types of uncertainty within product industries (Nelson & Winter, 1982). From a technology perspective, there may be uncertainty about which of the early alternative technical designs will emerge as the dominant paradigm within the industry (Abernathy & Clark, 1975; Anderson & Tushman, 1990). A given product's core technology may evolve along a number of possible trajectories and design hierarchies (Clark, 1985; Dosi, 1982), which cannot be accurately predicted in advance. For instance, consider introducing a new technical component within a computer. While it may improve the computer's processing speed, it may come at the cost of increasing the heat emissions leading to other issues. The purely technical dimension is often captured by using the technology "S curve," which plots the evolution of that particular technology along a key performance parameter as more research and development effort is put in (Cooper & Schendel, 1976; Foster, 1986).

The demand side of the market has a different perspective on uncertainty. One aspect relates to whether customers want to purchase a product because they are not sure what the technology is, what functional and technical characteristics really matter, and whether they really need it (Abernathy & Utterback, 1978; Utterback, 1994). In the automobile industry, for example, Ford quickly learned that many standard features on the Model T did not satisfy what customers actually needed – the cars lacked power to climb hills and waterproofing to protect against the rain in the Northwest region of the United States (Franz, 2005). A second aspect of market uncertainty relates to how customers actually use the product and its performance within a specific use context.

Customers may be uncertain about the internal changes required to implement the technology and how best to use a technology to achieve desired goals (Leonard-Barton, 1988). An example of high levels of use uncertainty would be the early introduction of the computer. When faced with computers for the first time, many customers did not know what they should use it for, how they should use it, or even how to install it (Fisher, McKie & Mankle, 1983; Yates, 2005).

It is important to realize that market and technical uncertainty are related but distinct. For example, market uncertainty can occur during periods of technological certainty. Customers may re-introduce performance-related uncertainty by changing how they use the technology without being pre-empted by a technological change (Kahl, 2007; Tripsas, 2008). For example, within the tabulating industry, Yates (1993) showed how insurance firms changed their use of tabulating machines from mostly computational work in actuarial studies to data management work in records management. This emerging use changed the performance criteria and required subsequent technological changes.

During periods of high technology and market uncertainty, buyers may be reluctant to purchase new products. One reason is that uncertain technologies often are unproven in a market sense – they lack of a demonstrated record of successful use. In the absence of a proven record for a particular product or technology, it is hard for buyers to engage in the exchange that leads to purchase and adoption (Rogers, 2001). New technologies and products may also become obsolete or replaced before they become established. Carpenter and Nakamoto (1989) have shown that, in the presence of technological uncertainty, buyers tend not to commit themselves to product-specific learning – adopting instead what is commonly referred to as a “wait and see” attitude. Selling services, such as pre-purchase consulting, can lower these concerns leading to earlier adoption. Moreover, implementation, training and support services can help customers feel more comfortable as well as improve the “fit” between a new product technology and customer needs. Leonard-Barton and Sinha conclude that “attaining productivity increases may be less related to how well a system initially fits a user environment than to how well developers and users make alterations to achieve these desired benefits” (1993: 1135). Through services, knowledge and skills about the new products are gradually transferred from the vendors to the buyers via “on the job” and vicarious learning (Manz & Sims, 1981) or later through buyers “poaching” talent from the service-providing unit (Gardner, 2002) once the new products have proven to be useful. In other words, by lowering the risk of early adoption, services allow firms to “hand hold” potential buyers and educate them on the advantages of the firms’ new products or technology.

Beyond adoption, producers also have incentives related to product development to provide services during periods of uncertainty. Even though producers of technology may be able to anticipate how a technology may be used, they cannot fully predict it (Chesbrough, 2003; Kahl, 2007; Kline and Pinch, 1996; von Hippel & Tyre, 1995;). Consequently, variations in how customers use the technology can be an important source of information for future technological considerations (Rosenberg, 1983; von Hippel & Tyre, 1995). In fact, Tripsas (2008) observed how customers in the typesetting industry began using the technology to print images, which in turn led to subsequent product innovation.

Therefore, high uncertainty negatively impacts adoption while also presenting opportunities for producers to collect valuable product information. Under these conditions, services can become a key mechanism to reduce buyers' reluctance to purchase the product and to increase producers' knowledge about buyer needs. By purchasing services such as consulting, buyers learn more about one or more alternative product technologies before they have to make a decision. Or they can purchase technical support, training, and implementation services in order to minimize the possible problems with bringing a new product technology into the organization. Product firms, in turn, can collect a wealth of information from their service interactions with buyers that can feed their technology development and product design. In short, the provision of services allows firms in the industry to lower the buyers' upfront investment in learning and adapting to new products and technology, while at the same time learn about the evolving buyers' needs – what Dougherty has termed the "technology-market linking" (1992: 181). We propose:

Proposition 1. The level of technology and market uncertainty will be positively related to the level of services in a product industry.

The level of uncertainty also has an effect on the type of services being offered in the industry. Uncertainty is associated with variation and change (Nelson & Winter, 1982), making it difficult to codify the knowledge (Szulanski, 1996) obtained in providing a service as well as transferring it (von Hippel, 1988) to other customers. In addition, without well-codified knowledge and established patterns, it is difficult to infer causality (Polyani, 1966) – in this case, what causes a successful product sale and implementation. This causal ambiguity, along with the codification and transfer problems, limits the producer's ability to construct and distribute a standardized service. Even if the producer could create a standardized service, it is not clear that it will properly be applicable to a broader market segment, given the changing needs and technologies. In contrast, during periods of low uncertainty, the lower levels of variation and change facilitate codification, knowledge transfer, and causal inferences which collectively support building standardized solutions. Aided by clearer and more stable customer requirements and technology, companies can write more complete and specific service contracts, thus favoring an arm-length relationship between service provider and customer, and therefore providing an additional boost to service standardization (Mills, 1986). Greater standardization in service provision and the existence of good contractual arrangements in turn helps the replication of service routines across different organizations. Therefore, given the problems associated with codifying, transferring, and building standardized solutions during periods of high technology uncertainty, we propose:

Proposition 2. The level of technology and market uncertainty will be positively related to the level of customized as opposed to standardized services offered in a product industry.

SERVICES AND COMPLEXITY

The level of uncertainty is not the only dimension that influences the nature and importance of services in a product industry. Services may also play an important role in the case of complex product technologies. Traditionally, the technology literature has defined product complexity strictly in terms of its technological characteristics, with respect to the number of components and elements included in a product class (Utterback, 1994). A new shovel design, with only a few simple parts that are easily assembled, is substantially less complex than an automobile or a computer, with many different parts, many of which require precise assembly. More recent literature has extended this notion by looking at the design, production, skills requirements, and diffusion of complex products and systems -- large and expensive capital goods typically sold in small quantities (Davies & Brady, 2000; Prentice, 1997). Much of this work builds upon Simon's (1962) notion that complex artifacts are composed by a nested hierarchy of subsystems. In general, this literature stresses that complex technological products and systems present unique inter- and intra-organization challenges that go beyond those typically considered under a "product class." For instance, Rosenkopf and Tushman (1998) argue that, in technologically complex industries, community-wide networks such as technical committees, task forces and standard bodies influence the process of technological evolution.

However, as with uncertainly, product complexity can also be thought of in terms of its use characteristics. Leonard-Barton (1985) defines complexity in terms of the technology requirements and the criteria and effort required to get the product into use. Products are seldom "plug and play" for buyers, but instead require significant changes of practices and routines at the receiving end as well as integration with other technologies (Edmonson, Bohmer & Pisano, 2001). From the user perspective, a highly complex product may require significant integration with other technologies or organizational changes in order to use the technology. This "use complexity" is important to consider because often customers are oblivious to the technical complexity of a product – most customers do not open the hood of their automobile to tinker with its engine or the 15,000 or so discrete components, nor do they interact with the sub-systems of a computer other than its user interface.

Based on these criteria, a mainframe computer, for example, would be high in technical and use complexity, whereas an automobile is high mainly in technical complexity. Both automobiles and mainframe computers are technical complex products consisting of many inter-related subsystems comprising a variety of technologies. However, to get a mainframe computer operational within a specific context usually requires extensive user training, at least some software customization, and integration with other systems such as different applications, communication networks, databases, storage media, and other peripheral equipment. In contrast, to use an automobile requires much less training, minimal or no product customization, and limited integration with other systems and technologies.

Uncertainty and complexity are often correlated, but they are distinct. Low complexity products in a technical sense can experience high market uncertainty while high complexity products can experience low levels of market uncertainty. For example, at the turn of the twentieth century, the horse-and-buggy – a relatively low complexity product – had a very uncertain future after Ford introduced the inexpensive, massproduced Model T in 1908. Even though the new automobile was a much more complex product, it was clearly here to stay and its future more certain, we might argue, than the horse-and-buggy.

Nevertheless, greater product complexity will tend to increase the upfront investment required of buyers if they want to adopt the new product technology, both in terms of financial resources and capability development (Davies & Brady, 2000). As was the case with uncertainty, greater complexity discourages buyers from adopting the new technology. Buyers can also perceive product complexity as increasing the probability that the product may fail due to the sheer number of components and sub-systems as well as possible misalignments during implementation (Leonard-Barton, 1988), rendering the investment unproductive.

The provision of services by firms in the industry can reduce buyers' reluctance to try a complex product. Training can open up the "black box" of the technology, explaining how the features or sub-systems work and increasing customer understanding of the product. In addition, implementation or maintenance services can resolve issues associated with the complexity of using a new technology. At the same time, warranty and maintenance agreements provide assurances that, if something goes wrong with the complex product, the vendor will fix it. Therefore, we propose:

Proposition 3. The level of technology and use complexity will be positively related to the level of services in a product industry.

Similar to uncertainty, the level of complexity also has an effect on the type of services being offered in the industry. In the case of uncertainty, both the technical and use aspects favor customized services because, under these conditions, it is difficult to codify and transfer knowledge as well as to build standardized service solutions that solve problems for a general audience. However, in the case of complexity, the cause and the effect differ from uncertainty. The main issue with complexity is that it generates localized knowledge, making it difficult for product companies to offer a more standard services solution. Thus, in general, lowering the technical or use complexity of a product should lead to more standard solutions and less need for customized services but, as we explain below, we believe this effect is more pronounced for use complexity than for technical complexity because the former directly affects the customer.

First, let us explore the relationship between technical complexity and standardization of services. Services can be standardized even in the presence of technically complex products if these products feature high levels of standardization or modularity. In other words, standardization and modularity should reduce technical complexity (Baldwin & Clark, 2000; Henderson & Clark, 1990). Product standardization allows the production of services to be less product-specific (as in the case of oil changes for automobiles) and possibly more automated (as in the case of web-based applications such as for travel reservations or information search). Greater product standardization generally implies a smaller number of product variations or different components, allowing service providers to gradually develop "service blueprints," i.e. specialized routines to carry out high-frequency services (Chase and Aquilano, 1977). Modularity may also reduce technical complexity such as by clearly demarcating sub-systems and establishing more standard interfaces between these systems. Increasing standardization and modularity within the product seems to support increasing standardization of services for the product should these be necessary, ranging from presales consulting to training, support, and repair. The automobile industry appears to support this intuition. Increasing standardization of parts and system interfaces within the automobile has supported more generalized service options such as oil changes, brake and tire services, and repair work. We can also see this in the computer industry, though perhaps less clearly than with automobiles because of the wide variety of computer products.

Standardization of computing platforms, including elements such as hardware processors, operating systems, and programming interfaces, began with IBM's System 360 in the mid-1960s. This new family of compatible computers made services such as hardware and software maintenance as well as custom programming easier to repeat across different customers – that is, to standardize. This standardization also made it possible to package common features in what had been customized software – so we have, finally, a software products industry emerging during the 1960s where we only had services before.

Let's now explore the relationship between use complexity and the standardization of services. Use complexity increases the need for customized services because of the local nature of the knowledge required and generated. If the use of a product requires significant integration with other systems and the development of organizational skills and processes, the knowledge required to sell the product as well as the knowledge generated from its use tends to be localized. Despite the overall trend towards standardization in the computer industry described above, large enterprises still have many complex, non-standardized requirements that prompt them to demand large amounts of customer-specific services (consulting, special programming, implementation assistance, technical support, maintenance, etc.) to use network of computers to perform tailored applications (Campbell-Kelly, 2003; Campbell-Kelly & Aspray, 1996). Customers also have found consulting and customized services useful to facilitate the transition from one computing platform generation to another, such as from mainframes to personal computers, or personal computers to internet-based applications. We can see this, for example, in the large number of IT consulting firms created during the internet boom in the latter 1990s (Cusumano, 2004, 2008). As a result, the knowledge learned at one location may not apply to another location or customer. In addition, given the level of information and its tacit nature, the information is sticky (von Hippel, 1988), making it difficult to transfer from one situation to another. The localized nature of this knowledge and its stickiness, make it difficult to create fully standardized service solutions. Therefore, we propose:

Proposition 4. The level of use complexity or localized knowledge required will be positively related to the level of customized as opposed to standardized services offered in a product industry.

Finally, it is instructive to consider extreme cases where technological uncertainty and complexity are both at high levels. Whereas, for the most part, product and services tend to complement each other, at very high levels of uncertainty and complexity, services can become a substitute to product adoption, at least for awhile. That is, instead of purchasing an expensive product based on a very uncertain or complex technology (such as most automobiles before 1908, when the Ford Model T appeared, or mainframe computers during the early years of the industry), buyers may prefer to pay for a service – such as a custom-built automobile or computer system. When this is the case, the relative importance of services in a product industry (with respect to products) would be at its summit. The industry's products would actually be sold as services (see Figure 1).

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Insert Figure 1 about here

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More examples may help illustrate this apparently counter-intuitive idea. The history of the mainframe computer industry and associated services, as summarized in Fisher, McKie and Mancke (1983) and Attewell (1992), provides a good illustration of this and other points we make in this paper. Early computers for business use were complex and expensive machines based on a new, largely unknown technology. Given their complexity and newness, acquiring a mainframe computer was "not just a matter of purchasing objects (the computer and software) but required considerable skills" (Attewell, 1992:9) -- skills that most buyers did not have in-house. As late as 1982, 70% of US businesses under 20 employees had no in-house computer specialist. Buyers' reluctance to invest in the new and expensive technology meant that, "A two-stage process in which firms initially purchased computer data-processing *services* from other organizations, and later purchased in-house computers was especially important in the early decades of diffusion" (Attewell, 1992:9, emphasis in the original). Computer manufacturers, such as IBM and Honeywell, all opened large services units because “the provision of such support services by manufacturers greatly facilitated the marketing of their equipment to users by reducing the users’ risks in installing that new, unfamiliar, and expensive object, the computer” (Fisher et al., 1983:172). The remarkable importance of services in the early computer industry led Atewell to note that “the theoretical importance of the service bureau as an agent of technological diffusion has not been recognized by scholars.” (Fisher et al., 1983:10). Overall, we can consider this customization work and other services as substitutes for standardized products, which became much more common later on.

Proposition 5. At very high levels of technological or market uncertainty and complexity, services can act as substitutes for an industry’s products.

SERVICES AND COMPETITIVE DYNAMICS

So far, we have only considered the fundamental relationships between the level and type of services and technological uncertainty and complexity. We have not considered the implications of industry life cycle stages on the nature of services – the original premise that drives much of the early thinking about services. Beyond variations in uncertainty and complexity, the competitive dynamics can change and result in changes involving service offerings. Under some competitive conditions, firms may choose to offer services in order to differentiate their products and remain competitive. Therefore, it is also important to consider the different competitive conditions that affect the level and type of services a product company might offer. The industry lifecycle literature provides a means to think about the relationship of services, uncertainty, and complexity, as well as these competitive dynamics, despite the fact that not all industries exhibit lifecycle effects and that even within an industry, lifecycle effects may be different depending for different countries or institutional settings (Murmann & Homburg, 2001).

Even though scholars emphasize different drivers of industry evolution, they agree that, as industries evolve, there is usually a milestone period where changes in the industry structure occur that alter "the resource conditions associated with competitive advantage" (Agarwal, Sarkar, & Echambadi, 2002: 976). What is often called the "onset of maturity" divides the industry lifecycle into two clearly identifiable stages, each with its own specific competitive dynamics. Before the onset of maturity, growth through product innovation is the primary competitive driver. Product design alternatives exist and change rapidly, propelled by a growing number of new entrants who come up with different designs or entirely new technological approaches. The competitive dynamics focus on product innovation and performance while processes tend to be flexible, with high manual content, and rely on general-purpose equipment (Abernathy & Utterback, 1978). After the onset of maturity, there is an increasing role of standardization and economies of scale (Gort & Klepper, 1982, Utterback & Suarez, 1993), and a consequent focus on process improvement. The mature stage brings important changes in the competitive dynamics as firms begin to focus on cost-competition (Agarwal, et al., 2002; Gort & Klepper, 1982; Utteback & Abernathy, 1975).

Under these two different competitive conditions, firms may make different strategic choices that either increase or decrease their service offerings as well as their importance to the business of the firm. The competitive dynamic of product innovation clearly is associated with high technology uncertainty: there is significant product variation within and between technology alternatives as firms experiment to find the best solution (Abernathy & Clark, 1975; Anderson & Tushman, 1990). The automobile is a classic example as early on there were three main technology variants: internal combustion engine, steam, and electric. Many early automobiles were modified horse-and-buggies, hand-built for individual customers using one of the new engine technologies (Eckermann, 2001). In line with our earlier propositions, these competitive conditions would seem to dictate high levels of customized services. Customized services have helped customers adopt and use unproven technologies, during periods of high levels of technological uncertainty, ranging from new types of propulsion at the turn of the twentieth century to new uses for the internet in the 1990s.

However, this prediction seems to contradict the intuition in the services literature that services increase mainly during the mature industry stage. In addition, not all industries appear to have high levels of services even during periods of significant product innovation. This may depend on the degree of use complexity. For example, during the 1970s, several firms in the United States, Japan, and Europe introduced incompatible technologies for home-video recording. These included devices such as Sony's Betamax, Japan Victor's VHS, and Phillip's video tape recorder, all of which used FM signals encoded on plastic magnetic tape housed in cassettes. There was also RCA's video disc, which used lasers to write on media that resembles today's CDs and DVDs, and other new technologies. Each of the alternatives was highly complex technically to design and manufacture. But, even when the first machines appeared in

1974-1975, thousands of users in Japan, the United States, and Europe bought one of these devices without much need for services such as consulting or product customization. At the same time it is also true that a content industry to provide prerecorded tapes would later help determine which company won this battle because of the network externalities involved in choosing an unpopular format (Cusumano, Rosenbloom, & Mylonadis, 1992; Rosenbloom & Cusumano, 1987).

To distinguish between these cases requires considering other dimensions of uncertainty and complexity. Despite the fact that periods of significant product innovation are typically associated with high technological uncertainty, they can vary in levels of market uncertainty as well as product and use complexity. Even though an industry's product may be going through significant technological changes, the market may be more certain about how it satisfies user needs (Kahl, 2007). For example, the insurance market lowered the uncertainty about the computer by comparing it to and using it like tabulating machines (Yates, 2005). In fact, producers may create design features to help customers think of the products in light of previous technologies to minimize this uncertainty (Hargadon & Douglas, 2001). As a result, lowering the level of market uncertainty can lower the need for customized services. In addition, products vary in terms of product and use complexity. The product and use complexity of a computer, for instance, is much higher than mass-market consumer electronics products, such as a VHS video-cassette recorder or an Apple iPod. We proposed earlier that higher levels of product and, in particular, use complexity generate the need for more customized services. Therefore, we propose:

Proposition 6. In competitive environments that exhibit high levels of product innovation, the level of customized services will increase with the level of market uncertainty and product's use complexity.

In contrast, the lifecycle literature argues that under conditions of cost competition, firms focus less on product innovation and more on improving efficiency. In some cases, these competitive dynamics are also accompanied by commoditization that creates pricing pressure on products. The lifecycle literature associates these periods with lower technology and market uncertainty as well as reduced product use complexity. The effect of deeper cost-based competition is reflected in an increasing pressure to standardize products and processes and reduce prices (Agarwal, et al., 2002: 976). These changed industry conditions result in a potential new role for services.

In the presence of strong cost pressure, services can help offset the effects of a decline in product revenues and profits. Almost by definition, given the fact that they are related to the installed base of products, service revenues may outlive product revenues (Knecht, Leszinksi, & Weber, 1993; Potts, 1988). A given product may produce a stream of service revenues long after it is sold, and even after a particular product has been discontinued. For example, there are recurring service revenues long after the initial purchase of an automobile – general maintenance such as oil changes and replacement or repair of worn out parts such as brakes, shock absorbers, mufflers, and tires. There are also many years of recurring maintenance payments and other services for users of mainframe and other enterprise-class computer hardware and software.

The nature of services often makes it possible for firms to create real or perceived differentiation in the market, preventing services from suffering the same cost-reduction pressures that characterize product competition. There is also evidence that some premium services may generate higher margins than the products themselves (Anderson, Fornel, & Rust, 1997). Services may then become a major source of revenues and profits when product companies have trouble selling their products or if prices decline sharply, which has happened in segments of the computer software, hardware, and telecommunications industries in recent years (Cusumano, 2004, 2008). Because of these trends, some researchers have focused on helping product firms make a successful transition to a more service-oriented revenue portfolio (Oliva & Kallenberg, 2003).

Even during intense cost-based competitionm services still provide valuable information for producers on what product variations matter to customers. Cost-based competition does not prevent some firms from trying to differentiate their market position. For instance, firms in a mature product industry may compete on the basis of small variations on a product – a trend labeled “de-commoditization” by Abernathy, Clark, and Kantrow (1983) – or around aesthetic or “symbolic” differentiation (Eisenman, 2004), such as from advertising. Moreover, Floricel and Dougherty propose that firms competing in commoditized environments may still renew their innovation capabilities by engaging in a “knowledge reproduction cycle” (2007: 67). Services can provide firms the necessary knowledge about customer information to attempt differentiation during times of cost competition.

Moreover, services can directly contribute to profits. In our mainframe computer industry example, most product firms had opened service units by the late 1960s because they "saw an opportunity for profits." (Fisher et al., 1983: 316). Services remain even today a profit-making activity for most computer firms selling to enterprise customers and other large organizations such as governments (Austin & Nolan, 2000). In our automobile industry example, companies such as General Motors and Ford in recent years have earned their only profits from financing (loans and leasing) as well as insurance while they lost money on their gross product sales (General Motors, 2007: 53, 66; Ford Motor, 2007: 34), though General Motors earned some revenues from telematics services through its OnStar offering. For the automobile industry overall, including both vehicle manufacturers and complementor firms, we know that financing, insurance, maintenance, and repairs have long been major sources of revenue and profits (Gadiesh & Gilbert, 1998).

The implication is that services can help prolong the lifecycle of a cost-driven product industry in the late stage by extending its stream of revenues and providing additional sources of profits. However, providing these services creates additional costs because these activities require different capabilities than product development and production (Nambisan, 2001). Service activities are also generally more labor intensive and costly, with lower profit margins, than mass production of standardized products. Expanding highly customized support services, for example, requires adding new personnel or re-training existing personnel about specific client needs. Cost-based competition may prohibit some firms from building out these services or at least encourage the development of more standardized or even automated service solutions to maintain a lower cost profile. Therefore, we propose

Proposition 7. The strength of cost-based competition (commoditization) in a product industry will be positively related to the level of services in that industry

THE PROVISION OF SERVICES IN A PRODUCT INDUSTRY

Thus far, we have only talked about levels and types of services within industry and have not addressed the issue of who actually provides and appropriates the service revenue. This issue is significant because, in many industries, firms other than the producers also provide services. In the automobile industry, there are many service organizations independent of the automobile manufacturers, ranging from maintenance and repair to driver education as well as financing and insurance. In the computer industry, there are consulting, training, customization, implementation, and maintenance firms independent of the computer manufacturers or software product producers. Therefore, in product industries that also have service offerings, it is important to understand under what conditions the product producer should expect to capture a part or even the majority of the service revenue and profits compared to independent service providers.

We can consider two dimensions of services provision: the level of "product-specificity" and the level of "industry-specificity." We define the level of "product-specificity" of services as the percentage of total industry services that are exclusively related to the industry's products. Maintenance and repair, for instance, are services that in almost all cases are exclusively related to the given industry's physical product -- a high level of product specificity. Similarly, we define the level of "industry-specificity" of services as the percentage of total industry services provided by firms in the product segment of the industry. For example, mainframe computer producers in the 1950s provided most of the hardware and software services required by their customers, until independent firms began to emerge, especially during the 1960s (Campbell-Kelly, 2003; Campbell-Kelly & Aspray, 1996). Even today, telecommunications network equipment providers such as Cisco, Ericsson, or Alcatel tend to provide a large share of the services in that specialized industry. The automobile industry may represent a case of lower industry specificity, as some services (e.g. insurance) are offered by firms outside the automobile industry, such as insurance companies or other financial institutions. Product specificity and industry specificity of services do not necessarily go hand in hand. For instance, while financing in the auto industry represents a case of low product and industry specificity (financing not only relates to cars but to many other assets and investments, and car financing is often provided by firms outside the auto industry), other services, such as maintenance are high in product specificity (almost all services directly relate to autos) but low in industry specificity (independent service providers have a significant share of the market).

The degree of product specificity and industry specificity in services is likely influenced by the location of product-related knowledge. The locus of knowledge, in turn, seems related to the level of product or use complexity, and possibly technological or market uncertainty as well. Industry evolution also may affect the location of product-related knowledge in the value chain. For example, we pointed out that the early stage of an industry is often characterized by high product uncertainty and a small market with relatively few buyers and suppliers. Some other industries may continue in a state where there is high uncertainty regarding the viability of the technology or which design, if any, will become the standard. In situations with high uncertainties or particularly complex technologies, buyers may not be ready to invest in developing in-house service departments. If the markets are in an early stage or remain small, then potential service company entrepreneurs may not see large enough demand for them to risk creating independent service companies. Firms other than the product producer also may have little incentive to invest in providing complementary products for the new product technology. For a third party, investing in learning about a particular product technology in order to service it or produce complements for it entails several risks, chief among them the risk of choosing a product that will not prevail during the selection and retention process that takes place. In these situations, product firms are likely to develop their own service operations in order to reduce customer uncertainty and encourage customers to purchase and use their products.

Proposition 8. Product producers are likely to provide a larger share of product-specific services when there are high levels of technological or market uncertainty as well as use complexity.

We also can anticipate how the provision of services might spread beyond the product producers. As markets evolve and grow, technological and market uncertainty is likely to fall, resulting in greater clarity among users with regard to how to use a new product. Complementors should emerge enticed by the growing installed base of industry products, especially if these can serve as “platforms” for other firms to offer related products and services that make the platform product more valuable (Gawer & Cusumano, 2002). This network or positive feedback effect may increase as the market grows because specialization is possible and the industry may "de-verticalize," encouraging entrepreneurs to create independent services firms (Stigler, 1951).

In the automobile industry, for example, manufacturers routinely set up training and certification programs that transfer product knowledge to maintenance and repair shops. Computer manufacturers such as IBM and Digital Equipment Corporation followed the same strategy for their products during the 1960s and 1970s. In more recent years, Intel, Microsoft, Cisco, Palm, and other companies have devised an array of strategies and programs to assist or encourage complementors to offer products and services that increased the utility of the platform products and thus made them more valuable (Gawer & Cusumano, 2002).

Another potential factor is product modularity – the extent to which a product can be decomposed into several subsystems that may be designed independently but work together as a whole through well-defined interfaces (Sanchez & Mahoney, 1996). Some authors have argued that product modularity increases over time in an industry (Baldwin & Clark, 2000; Jacobides, 2005). Modularity can result in simpler designs and reduce the importance of product-specific knowledge possessed by the product firms, which could then encourage the creation of more independent service providers. By having a well-defined core and interfaces, the way a modular product interacts with other products should be clearer than in the case of an integral design (Ulrich & Eppinger, 2004). Modularity makes it less crucial for a third-party firm to know how exactly the product works because much of the product knowledge is "built into" the product's modular design. This in turn means that the product firms may have less of an advantage in the provision of services if their product simply becomes a "core module" with well-defined interfaces that link to complementors. With modular designs, buyers can even do their own installation and customization, or hire independent service providers.

This is indeed what happened in the computer business. IBM's System 360 mainframe architecture became an industry platform after the mid-1960s. IBM also de-bundled services from its product offerings after 1970. As a result, many other firms around the world began providing maintenance, integration, training, and customization services as well as building complementary products (Attewell, 1992; Cusumano, 2004). In the personal computer industry, we can see the role of de-verticalization and modularity even more clearly. Since the mid-1970s, with the exception of Apple, most firms in the PC industry have come to specialize in one horizontal segment (microprocessors, hardware boxes, operating systems, applications software, peripheral devices, integration services, custom software, etc.) rather than provide a bundled vertical stack of products and services as early computer products such as IBM and Digital Equipment Corporation once did (Campbell-Kelly & Aspray, 1996). We can also see this in the automobile industry – the more standardized the components have become, the easier it became for independent service providers (gasoline stations, repair shops) to provide maintenance and repair services. It follows that,

Proposition 9. Product producers are likely to provide a smaller share of product-specific services in the presence of industry-wide product platforms and higher degrees of product modularity.

DISCUSSION AND IMPLICATIONS FOR FURTHER RESEARCH

Within the study of services itself, we believe there are several additional avenues of research. One relates to the effect of services on the performance and survival of product firms. Services can potentially extend the lifecycle of an industry given the fact that they may increase after the peak in product revenues and last longer as well as have higher margins than product revenues in some cases (Potts, 1988). However, our analysis suggests that product firms may not always benefit directly from the rise of services, and that the size of the service pie they capture may depend on the stage of the industry lifecycle, the existence of complementors, and the extent of product knowledge transferred to other firms such as producers of complements.

For example, if their service offerings are indeed more profitable than their products, then product firms in this situation have a strategic dilemma. They need to consider the trade-off between giving away product information in order to attract more service providers and other complementors to their platforms versus keeping that knowledge inside and trying to capture a larger share of the services business. This idea has significant implications for decisions such as whether or not to establish large in-house service departments, or how much to manage product licenses, patents, and partnerships for service activities. As more product firms start to break out service revenues and costs as a business segment, it will become possible to analyze the consequences of different strategies.

We also believe that the study of services is important to other established research literatures within strategy and technology management. One promising area is the link between services and firm capabilities. As previous studies have argued, a change of business focus toward services – either because of lifecycle pressures or strategic choice – implies an important change in organizational capabilities (Nambisan, 2001; Oliva & Kallenberg, 2003). But we have argued here that the type and role of services in a product industry may vary depending on key characteristics such as uncertainty, complexity, commoditization, and modularity, all of which tend to vary with an industry lifecycle or in different competitive scenarios. This implies that product firms may need different service-related capabilities at different stages or under different conditions. Resource-based literature has shown that some firms may have capabilities better aligned with product development and design (exploration) while others have capabilities better aligned with process improvement (exploitation). Likewise, we expect product firms to have capabilities better aligned with the development of particular types of services compared to pure services companies in the same industry, whether it be computer software, automobiles, or other businesses. Future research could help sort out what exactly these capabilities are under the different conditions we have outlined here. Another growing research area is how capabilities get renewed and change over time. Focusing on services as a transfer mechanism between customer knowledge and firm capabilities suggests services as a means to introduce new user capabilities and knowledge into the firm. This connection suggests that further research on the relationship between service capabilities as a mechanism to renew and change product-related capabilities is necessary.

Another important link in the strategy literature is with the growing interest in "vertical disintegration". For instance, Jacobides argues that coordination simplification and information standardization in the value chain tend to be associated with the "emergence of new intermediate markets that divide a previously integrated production process between two sets of specialized firms in the same industry" (2005: 465). Although greater coordination and standardization tend to be associated with mature stages, we have pointed out here other possible reasons why services may flourish in a product industry and why those services may be provided by firms not in the product industry. In addition, our concepts of "industry specificity" (percentage of industry services provided by the product firms) and "product specificity" (percentage of industry services related exclusively to the industry's product), by placing emphasis not only on the spin-off of the industry service activities but also on the share of services derived from the interaction of an industry's product with complementors, suggest further nuances to the concept of "disintegration" in a product industry that go beyond traditional forms of vertical unbundling.

Finally, we believe this theory can inform research on technological trajectories and evolution. Although the technology evolution literature clearly recognizes the role and importance of customers in innovation prior to commercialization (Clark 1985; von Hippel 1988), the role of how customers use a technology in shaping its direction and pace of change is less understood. Early models of technological evolution portray customers only as adopters implying that their role simply is to buy the technology (see Leonard-Barton, 1988 as an exception). However, studying customers' use of a technology after their purchase decision provides valuable information for product dvelopment. Customers must implement the technology and learn things about the technology not anticipated by its production (Franz, 2005; Kahl, 2007; Kline & Pinch, 1996; Tripsas, 2008; Yates, 2005). These use-based processes have not been completely considered in our explanations of technological change. By defining services as a transfer of knowledge between producers and customers, services can be seen as an important mechanism for incorporating use information into the producer's technological decisions. Therefore, identifying what technical aspects are being serviced and how user information flows back into the firm can help inform how product companies make technical design and innovation decisions.

A theoretical contribution is most meaningful if it is empirically testable. We have spoken conceptually about levels and types of services, but the current technology literature provides some ideas for empirical research. Level of services can be measured as percentage of revenue contribution within an industry, as the number and types of services, or as the number of employees dedicated to providing these services in cases where services are bundled with product prices. Many firms are beginning to break out service revenues formally within their financial statements, which facilitates the data collection effort. The technology modularity and complex systems literatures (Davies, 2004; Murmann & Franken, 2006) is developing measures of complexity and standardization that can be transferable to service offerings. Moreover, we think that bringing services into focus can lead to more delineated and concrete measures of uncertainty and complexity. Both measures incorporate both a technical aspect as well as a use aspect, which can be separated and tested.

In conclusion, this paper has provided the building blocks for a theory that can explain the role and characteristics of services in product industries. Services embody the product and use-related knowledge that transfers between the producer and customer in activities associated with selling, financing, implementing, customizing, using, maintaining, and repairing products. By relating services to both industry-level dynamics and levels of complexity and uncertainty at the product and use level, we move away from the common belief that services only increase as an industry matures. These relationships should help delineate when we would expect to see higher or lower levels of services as an industry, a technology, and patterns of customer usage evolve.

Figure 1:

Custom vs. Standard Services

Need for Local Knowledge Due to Level of Complexity or Uncertainty		
Low	*No Productized Solution:* Commodity services (e.g. basic computer coding or data input, dry cleaning)	*Fully Productized Solution*: Standardized products reduce need for customization (e.g., Model T Ford, PC, Windows)
High	*Fully Customized Solution*: Services substitute for products (e.g. custom-built automobile or computer system)	*Highly Standardized Solution*: Automated services tailor standard product offering for each customer (e.g., Google search, Expedia travel, eBay trading)
	High	Low

Need for Custom Services

1

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