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Firms' transition towards green product service system innovators

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Firms' transition towards green product service system innovators

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Abstract

Within this paper we explore transition paths firms can take to become product service system (PSS) innovators. Applying the dynamic capability approach we study how three firms have developed PSS innovations in the mobility sector (Car2Go by Daimler AG, Connect by Hertz by The Hertz Corporation, Better Place). We explore the different paths the firms have taken originating from different capability sets.

Based on semi-structured qualitative interviews with project managers of successful PSS innovations we propose a framework that incorporates three major transition paths. We derive propositions for necessary capability sets for different firm types, the sequence of necessary capability sets along the innovation process and discuss different types of environmental gains realized through PSS.

Keywords: Innovation management, product service system, transition path, sustainability

1. Introduction

Industry but also academic scholars increasingly draw attention to sustainable technical solutions often labeled “green innovation”. While the topic has received already considerable attention in a number of engineering disciplines, it has been largely neglected in managerial research (BMBF, 2010). In innovation management related journals the number of

publications has just started to grow since about a decade covering 142 papers by the end of 2010 (Schiederig, Tietze et al., forthcoming).

Within this paper we contribute to this literature focusing particularly on the innovation process of product-service system (PSS) innovations (e.g. car-sharing, cloud computing, chemical management systems). Previous studies acknowledge that among different types of innovations (e.g. product / service, business model innovations) PSS have a particular potential to combine sustainability with economical firm objectives (i.e. profitability) to enhance competitiveness. The characteristics of the PSS motivate firms to develop resource efficient and effective systems due to economical considerations (White, Stoughton et al., 1999; Mont, 2002; Baines, Lightfoot et al., 2007; McDonough and Braungart, 2009).

While certain firms have already made successful transitions to PSS innovators, many firms are still focused on the developments of products or services. Hence, previous literature indicates that those firms likely have insufficiently understood how they should manage the transition to become PSS innovators on operational level (Mont, 2002). In order to support firms to develop towards PSS innovators, we explore in this paper the paths selected firms have successfully taken to become PSS innovators.

Based on semi-structured, qualitative interviews with project managers of successful PSS innovations we propose a framework with three major transition paths. Each path is illustrated by one case example. Our framework builds on the existing PSS literature complementing, for instance established concepts like ‘servitization’ and ‘productization’. Our empirical focus is on PSS innovations for mobility solutions as transportation is among the industrial sectors causing a major share of environmental harm (Eurostat, 2011).

The remainder of this paper is structured into six sections. The next section introduces two relevant theoretical concepts. The third section outlines our research approach. The findings from the case studies are presented in the fourth section. The fifth section covers the discussion of the findings. In the sixth section we highlight managerial implications. The seventh section concludes that paper and includes future research recommendations.

2. Theory

After an introduction to PSS concept we present the dynamic capabilities approach which we have applied along the case studies.

2.1. Product Service Systems (PSS) innovations

Recently Baines, Lightfoot et al. (2007) identified and reviewed existing and often cited PSS definitions. Accordingly, Goedkoop (1999: 18) was the first to provide a formal definition for PSS as “a marketable set of products and services capable of jointly fulfilling a user’s need... [The PSS] is provided by either a single company or by an alliance of companies. It can enclose products (or just one) plus additional services. It can enclose a service plus an additional product. And product and service can be equally important for the function fulfilment.” Following his definition others provided slightly adjusted and more precise definitions (e.g. Mont, 2001; Centre for Sustainable Design, 2002; Brandstotter, Haberl et al., 2003; Manzini and Vezolli, 2003; Wong, 2004; ELIMA Report, 2005). Recently, McDonough and Braungart (2009: 111) also provided a definition for PSS labeling it as “product of service”. Accordingly, the authors describe PSS as “instead of assuming that all products are to be bought, owned, and disposed of by ‘consumers’, products containing

valuable technical nutrients – cars, televisions, carpeting, computers, and refrigerators, for example – would be reconceived as services people want to enjoy. In this scenario, customers (a more apt term for the users of these products) would effectively purchase the service of such a product for a defined user period..., rather than the ... [product] itself.”

When applying the available definitions to the case examples we had compiled, we found that the available definitions are hardly precise enough, particularly when applying a rather strict meaning of environmental gains. From extensive discussions in our research team we came to conclude that PSS innovations incorporated at least five characteristic elements. While certain of these five elements are incorporated in the existing definitions, few of the elements reach beyond the existing definitions. Firstly, PSS are considered an integrated offering of tangible products, intangible services and the enabling infrastructure. Secondly, PSS provide a product-unspecific functional use value (e.g. “always clean clothes” instead of purchasing new shirts one after each other). Thirdly, the ownership of all components remains with the offering firm who operates the PSS. Fourthly, an enduring contractual relationship exists between user and offering firm (i.e. instead of a single purchase contract as often characteristic for product sales). Fifthly, the user becomes temporary proprietor enabling a high use-flexibility. Hence, we propose to define PSS as *“an integrated offering of tangible products, intangible services and the enabling infrastructure providing a product-unspecific functional value. While the user and the offering firm engage into an enduring contractual relationship, the ownership remains with the offering firm with the user becoming the temporary proprietor enabling a high use-flexibility.”*

It has often been argued that PSS offer firms the possibility to combine their economic objectives (i.e. profitability) with sustainability (e.g. Baines, Lightfoot et al., 2007; McDonough and Braungart, 2009). For instance, Mont (: 239) explicitly pointed out that PSS can minimise the environmental impact of consumption by four measures: “Closing material cycles and re-use of components in next generations; Reducing consumption through alternative scenarios of product use; Increasing overall resource productivity and dematerialisation of PSSs; Providing system solutions seeking the perfection in integrating system elements along with improving resource and functional efficiency of each element.” As McDonough and Braungart (2009) pointed out, PSS have a potential to increase resource efficiency but also enable the combination with other environmental concepts such as the Cradle-to-Cradle approach. However, not all PSS provide similar environmental gains. Tukker (2004) studied the environmental benefit in terms of factor-4 contribution potential analyzing eight different PSS types (Weizsäcker, Lovins et al., 1998). He found that particular the “functional oriented” PSS type has the ‘highest impact compared to a reference situation’. Our PSS definition is limited to this particular PSS type.

Having defined the PSS concept, the question remains how firm can develop PSS innovations and hence become PSS innovators. To approach this question we sought theoretical guidance from the dynamic capability approach.

2.2. Firms’ dynamic capabilities

In a Schumpeterian world of rapid technological change and creative destruction of existing competences firms have to innovate continuously to capitalize on their demanding environment (Schumpeter, 1934; Wiggins and Ruefli, 2005). The theory of dynamic capabilities describes a firm’s ability to develop internal resources and competences in regard to the changing environment. With its focus on internal firm skills, it integrates the resource-based view (RBV) of the firm and complements other strategic management frameworks that emphasize mainly on external competitive forces (Porter, 1980).

The underlying RBV states that superior structures and systems of a firm are the reasons for lower costs, higher product quality or performance (Barney, 1991). This superiority originates out of the firm-specific resources rather than the strategic positioning of the product in the market. However the resource based approach is rather static and does not incorporate market dynamisms or the transformation of a resource advantage towards a competitive advantage (Priem and Butler, 2001).

The theory of dynamic capabilities implements these missing aspects into the resource-based view (Teece and Pisano, 1994; Teece, G. et al., 1997; Eisenhardt and Martin, 2003; Barreto, 2010). It suggests that it is more important for the economic firm success to identify new opportunities and to organize effectively and efficiently than to concentrate on external competitive forces. Teece, G. et al. (1997) defines the term dynamic capabilities “as the firm’s ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments.” This ability of the strategic management allows a firm to create a competitive advantage and thus rents. There are three classes of factors that determine the firms’ dynamic capabilities: processes, positions and paths.

The notion processes incorporates all managerial and organizational processes within the firm. Thus they describe all internal sequences of procedures in a detailed way. Processes shall fulfill the functions coordination, integration, learning and reconfiguration. In this context coordination and integration can be internal (e.g. between single actors or divisions) and external (e.g. partnership between different firms or integration of an acquisition). Learning refers to the capability to connect new information to existing knowledge by repetition and experimentation. The learning processes include the competence of new opportunity identification. Reconfiguration describes the firm’s ability to perceive the changes in the environment and the competence to modify the organization of the firm accordingly. The term positions illustrates the specific internal and external assets of the firm. These assets do not resemble the fixed and current assets of a balance sheet as those rarely create competitive advantage, they rather describe intangible assets like tacit knowledge, experience and intellectual property within a firm. The notion paths include all strategic alternatives that lie ahead. As paths describe the technologies and markets a firm can occupy with the help of its processes, the available options are limited by the firm’s current position and the paths it has taken in the past, meaning that previous (non-)monetary investments and decisions restrain the firm’s scope of action. Due to this path dependency a firm is forced to follow a certain trajectory and explore technological or market opportunities along its way.

Thus, trough execution of internal processes a firm has the possibility to build up new competences and capabilities to react on changes in their environment. These processes include amongst others the identification of new business opportunities, integration of new knowledge into the firm’s asset base by learning or coordination/ integration of external partners. A strategic management that secures a competitive advantage with executing these processes efficiently and effectively has successfully implemented the “dynamic capability” into the asset base of the firm.

3. Research approach

The PSS literature has identified two primary starting points, based on firms’ resource and capability sets, from which they start transitioning towards PSS innovators. While a product based firm may servitize, a service based firm in contrast might productize (Tukker, 2004). However, from initial research we identified at least one further starting point from which

firms can evolve towards PSS innovators. A firm can be newly established (“new entrant”) with the clear intention to develop a PSS innovation. Hence, in addition to the two starting points identified e.g. by Tukker (2004), in this study we rather consider three types of firms. For each of the three starting points (e.g. original capability set of a product based firm) we selected one recent PSS innovation as a case study with the empirical focus on sustainable mobility solutions (see Table 1). The mobility sector is one of the three industrial sectors causing major environmental impact (Eurostat, 2011).

To explore firms’ transitions towards PSS innovators with a theoretical emphasis on firms’ dynamic capabilities we applied a multiple-case study approach (Yin, 2003). As – to our knowledge – research on firms transitions to PSS innovators and the necessary capabilities development is absent, we must consider the knowledge situation as “shallow, fragmentary, incomplete or non-existent”. Particularly for such situations Punch (2005: 147) recommends that case studies have a contribution to make. Also case studies “enjoy a natural advantage in research of an exploratory nature” (Gerring, 2004: 349). (Yin, 2003: 40) recommends case studies when observations are “so rare that any single case is worth documenting and analyzing.” While multiple case studies are more demanding than a single case they permit exploration of more reliable patterns and “augment external validity and help guard against observer biases” (Leonard-Barton, 1990: 250).

Case ID	PSS innovation	Originating firm	Nature of originating firm	Initial PSS market	Year of PSS development initiation	Year of PSS market introduction
1	Car2Go	Business Innovation at Daimler AG	Product based	Germany	2007	2008
2	Connect by Hertz	The Hertz Corporation	Service based	USA	n.a.	2008
3	Better Place	n.a.	New entrant	Israel	2007	2011

Table 1: Case study overview

Data for the case studies was collected from complementary sources. Primary data was collected through semi-structured interviews with persons highly involved in the development activities of the specific PSS (e.g. the project leader, responsible R&D manager). Interviewing key informants reduces the effect of informant bias (Kumar, Stern et al., 1993). The interviews covered four sets of primarily open questions: Firstly, the nature of the development process (e.g. which capabilities were acquired, when, from whom and how, formal process structure). Secondly, the actors that were involved in the PSS development (e.g. internal departments, joint ventures) and how the actor constellation changed throughout the transition (e.g. when were different partnerships established). Thirdly, how the PSS development was initiated (e.g. as part of the firm’s roadmap, through external partners). Fourthly, the motives of the firm to develop a PSS innovation (e.g. economic vs. sustainability objectives). Additional data was collected from secondary sources, particularly journals associated with the mobility industry, but also newspaper, reports and press releases published by the case study firms.

4. Findings

This section reveals findings from the three case studies presented in Table 1. Each case study follows a similar structure. The first part is largely based on publicly available, secondary

source data and describes the PSS with particular emphasis on its functional value.¹ The second part describes the PSS development process in chronological order covering the three elements of PSS innovations (i.e. product, service, enabling network infrastructure). We focus on how the firms' developed the necessary capabilities to develop and operate the PSS innovations. This part is primarily based on our interviews.

Car2Go - A PSS innovation developed by a production based firm

The car-sharing system Car2Go is a PSS innovation developed by the German automobile manufacturer Daimler AG. Instead of selling a vehicle, Car2Go offers the functional value of urban mobility to their users. The cost for the mobility is calculated on minute basis and includes the gas, insurance, mileage coverage, taxes and parking fees on designated areas. Different to other car-sharing systems, Car2Go allows one-way journeys, since the vehicles can be returned at any location within a defined inner city area. The latest vehicle generation is equipped with a 100 Watt power solar roof to continuously supply power to the telematic system, air conditioning and battery charging. Car2Go is "the world's first series-produced car-sharing model to be available ex factory". Car2Go is available in three cities (Ulm, DE since 10/2008; Austin-Texas, US since 05/2010 and Hamburg, DE since 04/2011) each day for 24 hours (Daimler AG, 2010b).

As similar to other car-sharing systems users have to register for the system once. Having paid the initial registration fee the member has an ongoing access to the Car2Go system (i.e. enduring contractual relationship). To be identified as a member, each user gets an identification sticker on the driver license. Available vehicles in the defined area can be found and booked 'spontaneously' online (e.g. with smart phones) or via a hotline. The user has to identify her-/himself with the sticker on the driving license placing it at a scanner situated beneath the front window of the car. The doors are unlocked upon successful identification. To start and operate the vehicle the user has to enter a personal identification number at a touch screen display on the interior panel. The screen is the user's interface to a telematic system for controlling the rental period and preventing theft (Daimler AG, 2008).

Development of PSS capabilities

In October 2007, Daimler AG established their front end innovation department "Business Innovation" with the purpose to explore potential new business opportunities and models. The team was formed consisting of 15 experienced managers allocated from Daimler AG's different departments being backed up directly by the company's executive board. Starting from a market and social trend analysis its objective was to sense opportunities and to develop technical solutions for future mobility (Daimler AG, 2010a). High urban traffic volume, decreasing importance of vehicles as status symbols among young people and the weaknesses of existing car-sharing solutions led to the development of Car2Go.

While developing the prototype it became clear that the telematic systems will be the enabling technology for the PSS (e.g. interconnecting the vehicles but also allowing the members to book the vehicles via the internet). Initially a telematic system was purchased from an external partner (i.e. Invers GmbH) as no competence existed in this area. In October 2008, Car2Go started with 50 vehicles as a pilot project in the German city of Ulm which has been a test market for various Daimler projects (Daimler AG, 2008). However, after proving the market potential and cumulating experience through prototype testing the team decided to

¹ For the secondary data collection we kindly acknowledge the support of Ozan Mahmutluoglu.

develop an own telematic system to fulfill the internal security and quality standards of Daimler AG. The development of an in-house solution allowed distinct functions as a seamless integration of the telematic into the steering and control panels of the car.

Besides the support of the mother company's development departments, the Car2Go team lacked the man power and market research capabilities wherefore it collaborated with marketing agencies and market research institutes in this early stage. In 2010, the project was extended to the US city Austin, Texas to explore the potential for the US market, especially the younger generation of urban vehicle drivers (Gregor, 2010). After two pilot projects in mid-sized cities, the Car2Go system was launched in Hamburg in April 2011. In contrast to the pilot projects, Car2Go partnered in Hamburg with the car-rental company Europcar. This new partner complements the necessary service capabilities to maintain and redistribute the vehicles as well as providing supporting infrastructure or complementary rental offerings.

Thus, we can conclude that Daimler started the Car2Go PSS project from the capability basis of a product based firm. The necessary network capabilities (i.e. telematic solutions) were initially acquired externally to accelerate the development process. Instead of establishing a research partnership to develop a solution collaboratively, the capabilities were internalized with the support of the mother company. Car2Go initially tried to develop the lacking service capabilities to operate a PSS internally as well but decided soon to partner in a joint venture with the rental firm Europcar that possesses the necessary service capabilities.

Connect by Hertz - A PSS innovation developed by a service based firm

The car-sharing club "Connect by Hertz" is a PSS innovation developed by the car-rental service company The Hertz Corporation (Hertz). The company offers the functional value of flexible urban mobility to the user instead of time-dependent single-contract pure rental offerings. The PSS innovation is currently available in the cities of Berlin, London, Paris, Madrid and New York. The user has to obtain a one year membership to access the vehicles in all cities 24 hours each day. The use period is flexible and may vary between one hour and seven days. Insurance, fuel, optional street charges and 20 km per hour are included into the price. Connect by Hertz operates vehicles of all brands with a focus on low-emission-vehicles (Hertz, 2011).

The basic process to participate in the system includes six steps. First the user has to apply for a membership to receive a membership card. Users can book vehicles online or via smart phones. Users receive the booking confirmation by phone for a vehicle at a nearby station. The doors of the vehicles unlock by scanning the membership card on a sensor at the front window. Once inside the vehicle the normal key is used to operate the vehicle. The key, vehicle registration certificate and petrol card remain always inside the vehicle. The vehicle has to be returned to the same station after usage.

Hertz always maintains the ownership of all PSS components. The vehicles are purchased from different manufacturers and outfitted with the required hard- and software. Through telematic components the vehicles are combined into a system that can be managed centrally by Hertz.

Development of PSS capabilities

Changing user preferences were the initial motivation for Hertz to develop a PSS innovation. Hertz sensed the opportunity that urbanization, job rotation and decreasing importance of the vehicle as a status symbol require new mobility concepts. The concepts shall offer high use

flexibility and be complementary to existing business models of the company. In 1997, Hertz entered into a strategic partnership with the Swiss car-sharing company Mobility to understand and analyze the required capabilities of the car-sharing business. In 2008, the company started their own PSS “Connect by Hertz” in New York, followed by London and Paris. Based on their service capability across different countries the company purchases the vehicles externally and initially partnered with the French company Eileo S.A., an experienced company in developing the network infrastructure components. Learning outcomes from first prototype testing of the system revealed the need to integrate additional functional features into the hard- and software. This resulted into the strategic acquisition of Eileo in April 2009 and the integration of their capabilities into Hertz through transfer of employees and trainings (The Hertz Corporation, 2009). Additional partnerships with housing societies, universities and private companies were signed to provide additional pick-up stations and broaden the infrastructure of the system further. Future plans include partnerships with vehicle manufacturers to increase the capabilities and knowledge in the products, particularly the vehicle control management.

Although implemented into the strategic roadmap of Hertz, the company developed the PSS innovation in an iterative learning process with the help of externally purchased components, partnerships and acquisitions. After the strategic acquisition of a telematic solution provider, the necessary infrastructure components (e.g. booking software, front window scanner, internet and GPS integration) are developed nowadays internally. The service components (e.g. customer service, station management, booking, maintenance), have been developed largely as an extension from the existing capabilities with regard to rental processes. The basic environmental benefit has already been monitored by the company through an increased utilization capacity of each vehicle and a lower travel-distance per user in comparison to their conventional renting service. Additional environmental benefits are limited to the use of low-emission vehicles.

Better Place - A PSS innovation developed by a new entrant²

New entrant Better Place (BP) has developed a PSS providing power supply for electric vehicles (EV). Since 2008, the firm has set up a network infrastructure of charging spots and switching stations in their pilot market Israel. The switching stations are operated by robotic shuttles exchanging the battery of the EV in less than 60 seconds without human assistance. BP purchases its electric power supply for their charging and switching stations solely from renewable energy sources (i.e. solar arrays and wind farms) (Thompson, 2009). Similar to the way that petrol cars are sold separately from their fuel, BP keeps the ownership of the battery packs with their system. BP users have not to care about battery life, degradation, warranty issues, maintenance, capital cost or quality. The first commercially available vehicle that is compatible with the system is the Renault Fluence Z.E with other manufacturers following (e.g. Nissan, Chery Automobile Corporation).

BP charges the users with a monthly fee for providing the necessary infrastructure. Additionally users are purchasing a functional value in terms of driving distance on “pay-per-mile” basis in an enduring contractual relationship. The initial costs for purchasing an EV can be subsidized by the ongoing pay-per-distance contract just as mobile handset purchases are subsidized by pay-per-minute service contracts. In addition the BP system offers a temporary storage for utility providers to intercept peak load through energy storage of un-used batteries.

² This case study largely refers to Kendall, 2008; Andersen, Mathews et al., 2009; Becker, 2009; Hatton, Beella et al., 2009; Brown, Pyke et al., 2010.

Development of the Better Place PSS capabilities

In 2005, Shai Agassi, a former board member of the German based IT-company SAP and well experienced with a system approach, developed the PSS idea based on initial discussions on the World Economic Forum in Davos, Switzerland. In October 2007, BP was established to develop a PSS innovation for sustainable mobility.

Besides developing a sustainable business model, BP needed to develop the different PSS components including the tangible products (EV, battery packs), the network infrastructure (charging spots, battery switching stations, but also a software for managing the system) and the necessary complementary services (energy management, customer service). As there was only limited R&D competence in the new firm BP's initial philosophy was to use existing technology to the extent possible. Resources should only be spend on own technological developments when no solutions were available on the market. It soon turned out that BP had to build substantial knowledge on its own in the development of switching stations and the network software solution. For this research BP's founded an own R&D facility in Tel Aviv, Israel.

First testing of the infrastructure prototype was conducted in Tokyo in April 2010 where an electric taxi demonstration project was launched in partnership with Tokyo's largest taxi operator and the Japanese Ministry of Economy, Trade and Industry. To offer private users electric vehicles to utilize the PSS solution, BP partnered since 2008 with Renault-Nissan, who developed several prototypes based on their capabilities in vehicle manufacturing. For the development of battery packages with an increased operating distance, BP signed partnership agreements with Nissan and NEC. BP also had to develop two software components. On the one hand a software had to be developed for the cars (i.e. to tell the user where the next charging station is), but also a scalable software for managing the whole charging processes of many thousand battery packs (i.e. two-way communication with utility providers).

Thus, we can conclude that BP started their PSS only with competences in system development. As BP is a new entrant, all capabilities had to be developed simultaneously. The firm decided to coordinate and integrate the missing competences through partnerships. The focus of recent partnerships laid on the development of the initially required product and infrastructure components. Within the approach of their pilot market, BP is currently developing the required service capabilities.

5. Discussion

The literature proposed two concept of how firms can evolve towards PSS providers. Baines, Lightfoot et al. (2007) discuss the servitization of product oriented firms and productization of service oriented firms. However, our research has revealed that there is at least one addition to the two paths where firms sense the opportunity and develop PSS innovations. In addition, firms can also be newly established to directly innovate PSS solutions. Hence, we can derive Proposition 1:

To innovate PSS solutions firms can build the necessary capabilities from three starting points.

Depending on the starting point (i.e. the firm specific asset base), three different transition paths exist to integrate the necessary knowledge for successfully innovating PSS. Those paths are illustrated in the path transition framework in Figure 1.

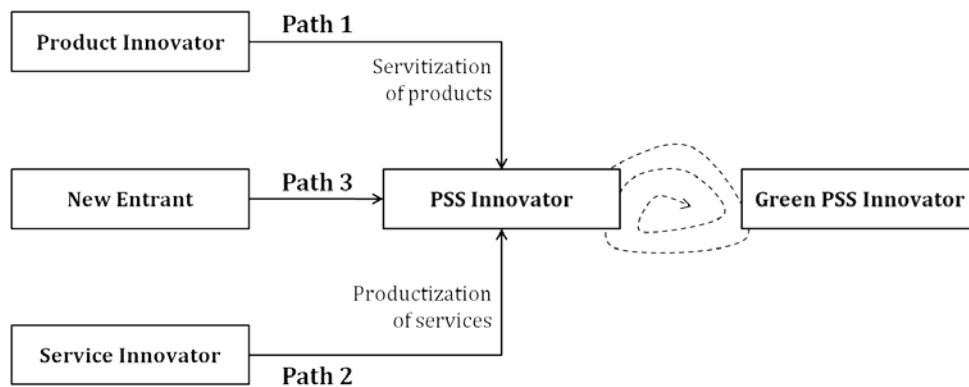


Figure 1: Framework of firms' transition paths to become GPSSI

A PSS is defined above consisting of three components, the tangible products, intangible services and the network infrastructure. The three case studies well reflect on the capabilities firms need to build (i.e. internally or acquire externally) when developing PSS innovations. In none of the three case studies any of these elements were available readily to be purchased from the market. Even the vehicles for the Car2Go system, the Connect by Hertz model and Better Place need to be adjusted for integrating the telematic systems or to host the battery pack. During the transition to become PSS innovators at least Daimler AG and Better Place needed to develop service capabilities to operate the PSS. Daimler AG decided to outsource the PSS related services after they discovered that they hardly possess these capabilities. The Hertz Corporation had started with a capability set of a service firm and maintained their service capabilities to operate the Connect by Hertz model. In all three cases we observed that the developing firms also needed capabilities to create the network infrastructure. Hence, we derive Proposition 2:

To develop PSS innovations firms require complementary capabilities corresponding with the three PSS elements: product, service and network infrastructure development capabilities.

Although we observed that firms need all three capability sets to develop PSS innovations, the three case studies showed that the need for the different capability sets might not be equal. While firms can purchase the necessary products often directly from the manufacturers (e.g. The Hertz Corporation purchasing vehicles) and outsource the service capability set (e.g. Car2Go partners with Europcar), all three firms internalized the network/infrastructure capability set. Car2Go first partnered with Invers GmbH using their telematic system but later decided to internally develop an own system using the internal development departments from the mother firm. The Hertz Corporation initially partnered with the French firm Eileo but later discovered the inherent need for the telematic system to control the PSS and internalized Eileo's network capabilities through acquiring the firm. Also Better Place, following its philosophy to conduct as little own R&D as possible, had learned at a certain point that the network capability set is crucial and internalized the development of it. From these observations, we derive Proposition 3:

The network capability set is the central capability set in order to control the PSS, wherefore firms internalize it.

Figure 2 depicts an illustration of the three complementary capability sets, where the network infrastructure development capability set is situated on top illustrating the importance as enabler to operate the PSS. We call the set of complementary capability sets for PSS innovations the "capability envelope". Following the dynamic capability reasoning, strategic management has to integrate the full "capability envelope" into the firm's asset base through

efficient and effective processes to become a successful PSS innovator. Firms can further develop towards green PSS innovators where the capability envelope would need to be extended with environmental capabilities.

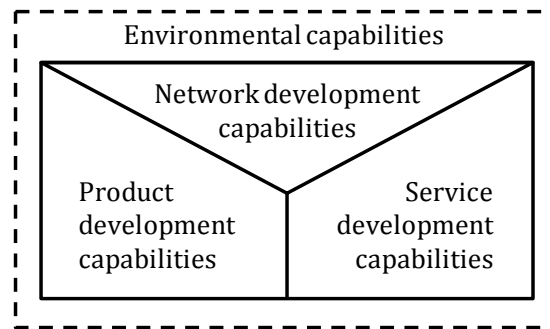


Figure 2: Capability envelope for PSS innovators

The case studies revealed the firms' need for three capability sets with the network development capability set being more important than the product and service development capability set and hardly can be outsourced. Furthermore, from the case studies we observed that the need for the different capability sets is not equal along the transition path. In all three cases it became obvious that the need for the service development capability rose very much later during the transition than the product and network development capability set. Hence, we can also formulate Proposition 4:

The need for the different envelope capabilities varies during the transition towards a PSS innovator with the need for the service development capability arising later in the innovation process.

Finally, we like to discuss patterns that we observed with regard to the environmental gains realized from the PSS innovations we studied. From our observations, we found three distinct environmental beneficial effects. First, we found that one part of the PSS's environmental benefits refers mainly to a benefit that is inherent in the PSS innovations, as also discussed by previous authors. This environmental benefit is realized 'automatically' with every transition from a product offering towards a PSS offering. For instance, when the usage of purchased vehicles (i.e. product sale) is compared to car-sharing systems, previous studies found that the car-sharing vehicles have a much higher resource utilization rate (Loose, 2008). Also the interviewee from The Hertz Corporation reported that the utilization of the vehicles used for Connect by Hertz is almost double than the utilization rate of vehicles in the firm's conventional rental business. This effect might be illustrated through the following example. During the week vehicle owners commonly use their vehicle for a trip to their workplace in the morning and back home in the evening where the vehicle remains parked and unused throughout the day. In contrast, in car-sharing systems every vehicle can be used by different members with different preference and use profiles also throughout the day.

In addition, in our case studies we observed another environmental beneficial effect that becomes also inherently available from every PSS system. However, in contrast to the first effect discussed above that is realized 'automatically' the second effect needs to be activated by the operating firm. Thus, the second environmental beneficial effect should be understood as a 'potential' that can be leveraged by the PSS operator. This effect is realized because of the PSS characteristic that the operator remains ownership and thus control over the whole system at any time. Assuming the operator to be driven primarily by economic motives, he has an incentive to optimize the lifecycle costs of the whole system, reducing the overall costs

in order to increase the profitability of the system. We argue that at least some of the measures the operator will likely conduct to reduce the operating costs of the PSS and hence increase its profitability will also contribute further environmental gains (e.g. through spillover effects). For instance, car-sharing operators such as Car2Go and Connect by Hertz include the gasoline usage in their fixed pricing models (i.e. flat fee per kilometer). Hence, the operator can increase the PSS profitability through the reduction of its operational costs, for instance by using fuel efficient cars. The operator, being a large scale customer of the vehicle manufacturer, might even possess enough purchasing power against the vehicle manufacturer to initiate R&D activities to improve combustion engine efficiency. For instance, The Hertz Corporation is among the largest customers of the large vehicle manufacturers. Although, the cost reduction potential is inherent in PSS innovations, it remains dependent on other determinants to what extent firms leverage the potential.

Furthermore, PSS innovations can be combined with environmental beneficial concepts such as the Cradle-to-Cradle approach as argued for instance by McDonough and Braungart . Mainly the argument rests on the characteristic of PSS that the operator maintains full control of the whole system and thus ‘closes the loop’ enabling recycling or upcycling of the materials and components used in the tangible PSS products (Mont, 2002). Hence, through PSS innovations additional environmental gains can be realized. However, firms have to undertake additional measures to realize the environmental gains, which are independent from the PSS characteristics and dependent on other determinants (e.g. the firm’s sustainability strategy).

To summarize, while certain environment benefits result automatically from PSS innovations through increased resource utilization it depends on the PSS operating firm to realize further environmental benefits as spillover effects from leveraging the cost reduction potential and through further environmental concepts that can be combined with PSS innovations, such as the Cradle-to-Cradle approach.

6. Managerial implications

To cope with the increasing need to continuously innovate firms should consider starting a transition towards PSS innovators to maintain their competitiveness.

To complete the transition to a PSS innovator, firms will need to acquire three complementary capability sets. These include a product and service development capability set but also a network infrastructure development capability set. Most likely the latter capability set appears critical to control the PSS innovation; hence firms might consider internalizing this capability set while the other two sets can be outsourced, at least to some extent. Firms should be aware that the need for the different capability sets differs during the innovation process, with the need for service capabilities likely to emerge later in the innovation process. Depending on the firm’s original capability basis, firms will need to take different paths to become PSS innovators.

As changing user preferences increasingly demand less environmental harmful products firms that have made the transition towards PSS innovators can develop further towards green PSS innovators. They can stepwise realize further measures leveraging the environmental beneficial potential inherent in PSS innovations and apply addition measures that can be combined with the PSS.

7. Conclusions

Focused on the mobility sector, in this paper we provided results from three case studies. Based on the dynamic capability approach we proposed a framework for firms' transition paths towards PSS innovators. We derived four propositions relating to three necessary capability sets necessary to complete a transition to a PSS innovator, the different importance of the capability sets along the innovation process and the different paths firms may take depending on their original capability set.

Having applied a focus on the mobility sector we recommend to broaden the perspective to also include two industrial sectors that contribute largely to environmental impact: Energy and waste. We further recommend enlarging the sample and turning to quantitative assessments also including measurements for the environmental gains that result but must be activated by firms applying additional measures.

8. References

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