Interaction of Product and Service Innovations
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An Analysis of the Dynamics in Industrial Companies

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Industrial companies increasingly rely on services to stand out from the crowd. Alongside direct strategic and economic advantages, these industrial services can also provide impulses for the further development of the producer´s good. Likewise, modifications of the material product may lead to new or advanced service offers. Hence, product modifications may lead to service adaptations, which again lead to product enhancements. Consequently, product and service innovations seem to interact, driving a dynamic loop and accelerating the innovation activities of a company. This article analyzes the causes by means of a literature review. Afterwards a system dynamics model is constructed to describe the assumed interaction system of product and service innovations in industrial companies and show first consequences resulting from this dynamic loop. Finally, the impacts of some drivers are tested, to give some insights into the behavior of this system.

System Dynamics, Manufacturing Industries, Innovation, Industrial Services

1 Introduction

In the past, industrial companies tended to focus strongly on material innovations. However, it has since become widely accepted that a more comprehensive understanding of innovation, one which takes innovations in services into account alongside material product innovations, can have far-reaching consequences for boosting competitiveness (see Dreher et al. 2005; Kirner et al. 2009). Services offered in addition to the core product, such as maintenance, repairs, training or engineering services, for example, aim to both bind customers and increase sales (see e.g. Boyt/Harvey 1997, Wise/Baumgartner 1999).

Apart from the strategic and economic significance of services, additional effects can be found in practice, such as, for example, additional information feedback from customer contacts due to services (see Lay et al. 2007). Beside these practical experiences, this phenomenon is also described in research (see e.g. Goffin/New 2001; Hobday et al. 2005). Such feedback can in turn provide incentives to improve or modify material products. An information cycle can be created due to the contact between the company’s employees and the product and/or customers which can deliver impulses for new ideas for products of industrial companies.

Thus, the offer of industrial services can serve as a stimulus for new products, on the one hand. On the other hand, other authors assume that the further development of products is also accompanied by changes or modifications in the range of services offered. The technological further development leads to additional or changed service needs on the part of the customer or in the customer's production process (see Meyer/Blümelhuber 1998; Busse 2005). In this context, the systemic character of products and services in industrial firms is emphasized, which results from such an integrated offer (see Duschek 2002).

Summing up, offering industrial services can function as an information channel for the further development of products. Furthermore, the enhancement of the material product leads to adaptations of the service offer. This leads to the speculation that there is a process over time in which product and service innovations encourage each other. The aim of this paper is to analyze these observed interdependencies and to investigate the following questions:

(1) How can this interactive system between product and service innovations be described and represented in a formal system dynamics model?
(2) How do various influential factors affect the system behavior and what possibilities do enterprises have to trigger this interaction process?

In order to answer these key questions, first of all a literature analysis is carried out which deals with the impacts both of products on service innovations as well as services on product innovations. By combining these two approaches, a dynamic hypothesis is derived and converted into a causal diagram. Based on the information from the literature, and with the help of the causal diagram, a formal system dynamic model is constructed which can illustrate the interaction of the product-service innovation system. Thereafter, simulation runs and tests will be conducted to analyze the impacts of individual factors and to obtain first insights into systems behavior. The article ends with a conclusion regarding the stimulus to the interaction process and an outlook to future research needs.

2 Linking product and service innovations

In order to be able to classify the relevance of services as triggers of new products based on the literature, a short review is made of existing work in this field. The literature analysis focuses on those papers which deal with the information channel of services or service contacts to customers and assesses its relevance as a source of inspiration for innovations.

Several articles have been written over the past few years on the identification or evaluation of industrial services as an information channel for triggering product innovations. Hobday et al. (2005), for instance, assume that the expansion of services demanded by customers automatically implies that closer contacts to customers will result. If these services are provided, a broader information basis results for the manufacturer, which involves accelerated learning processes due to feedback loops, and provides insights into potentials for product development (see Hobday et al. 2005).

The authors of another paper also assume that industrial services can make a decisive contribution to product development as a source of information (see Goffin/New 2001). They conducted a literature review in combination with five case studies. However, they state that industrial companies hardly use this channel as a source of inspiration for innovations. A formalized process supporting the flow of information between service workers and product developers is actually very rare. In addition, the majority of industrial companies organize the provision of services and the development of products separately, which halts the flow of information to a large extent.

Furthermore, several authors verified that the experiences garnered from using a product or maintaining or repairing it can be an important source of information for developing or improving products. And yet, in practice, this information was either not collected at all, or not used to develop products (see Markeset/Kumar 2003; Molenaar et al. 2002; Petkova et al. 1999; Thompson 1999). Similarly, Bitrain and Pedrosa (1998) see customer wishes and complaints as a useful source of information which ought to be used as feedback.

Finally, it should be noted that, the various articles agree that services could be an important source of information for industrial companies in product development. However, the information cycle resulting from this seems to be hardly used in practice or is not being recognized as such.

On the other hand, several authors describe the delayed development of service innovations after product modifications were carried out. Thus Meyer and Blümelhuber (1998), for instance, assume that changes or adaptations to the product trigger a demand for services in the customer. However, the resulting need would have to be recognized through a targeted monitoring of the production process. This could lead to the emergence not only of service modifications, but also completely new industrial service offers (see Meyer/Blümelhuber 1998).

This assumption is also discussed by Busse (2005). In this context, the author emphasizes the systemic character of innovations in the industrial goods sector. Due to the numerous compatibilities and interfaces which services should have to material products, adaptations to the service offers would then follow product innovations. Because of this systemic character, service innovations would thus depend largely on innovations in the material sector (see Busse 2005).

Finally, we can determine that some articles proceed from a direct influence of product innovations on service innovations. If this effect is coupled with the assumption of the impacts of service offers on product innovations, a loop emerges which accelerates the development of product and service innovations over time. The linking of these two mentioned effects can be formulated as a dynamic hypothesis in a causal diagram. This loop is depicted in Figure 2-1.

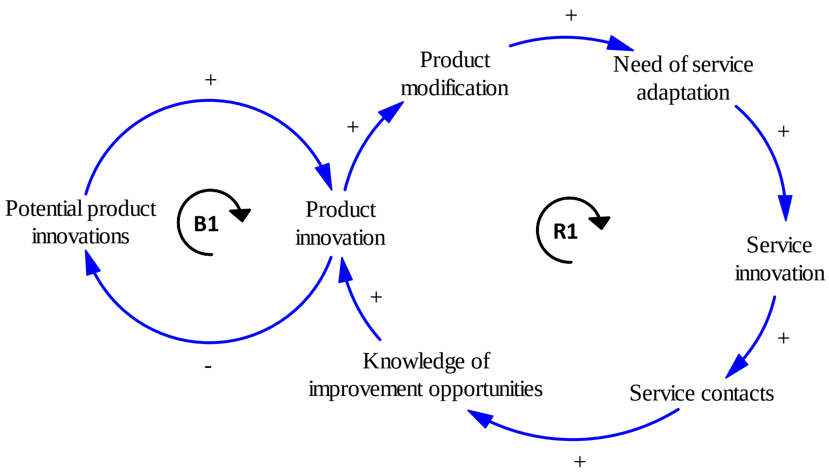

Figure 2-1: Loop for the interaction of product and service innovations

Starting from service contacts to clients, knowledge about improvement opportunities can be generated e. g. via maintenance and repairs to the material product. The employee gathers knowledge over time and therefore the accumulation of knowledge is to be seen as stock of the knowledge flow. Increased knowledge about improvement potentials can thus lead in the long term to an increase in the number of product innovations (effect described e.g. in Hobday et al. 2005; Goffin/New 2001). As illustrated above, innovations to the product increase the number of product modifications, which again causes a rise in demand for services on the part of the client. Recognition of this new and modified service demand, which also represents a learning process, again results in a higher number of service innovations (effect described e.g. in Duschek 2002; Busse 2005). This reinforcing cycle (Loop R1) is slowed down by a balancing loop. The technological potential of the product is exhausted by product innovations, making it more difficult to implement innovations in the material product (see Dosi 1982; Loop B1).

Thus the dynamic hypothesis shows that industrial firms with a range of services offered would more frequently carry out product developments than industrial enterprises without service offers. Equally, it can be proved that firms with a greater number of service contacts to customers exhibit greater innovation activities, not only for products, but also for services than companies with fewer service contacts. A first simulation model was constructed to demonstrate these assumptions, whereby the above causal diagram was converted into a stock and flow structure. The system structure is described in the next section.

3 System structure and basic elements

The simulation model has a simple system structure, which consists of three sub-systems. The sub-systems are described as the product development, the service development and the client structure.

The product development was greatly simplified and depicted according to Stumpfe (2003) (see Figure 3-1). Starting from a product potential, which describes the sum of all product innovations, product inventions are initially generated via two different channels. The product inventions thereby describe the technological status of the product, respectively, the possibilities of the firms to improve the product (Stumpfe 2003). In view of the problem, the R&D department as well as the service department were considered as the sources of innovation. The opportunities for product improvement of the R&D department depend on the present technological status of the product. The more exhausted the potential, the more difficult it will be to generate product innovations (see Stumpfe 2003, Dosi 1982).

If the dynamic hypothesis is followed, the company also has the possibility to generate product innovations via information gathered from customer contacts. This information channel therefore depends on the number of customer contacts, the number of customers, and the sum of the services offered. This channel is stimulated by the diffusion of the product in the market. How successfully this information channel can be utilized, however, depends to a great extent on the ability of the staff to recognize improvement opportunities in the product ("Learning Factor per Contact"). This constant can be changed from 0 per cent (no knowledge generation via customer contacts) up to 100 per cent (every single customer contact increases the knowledge stock). The product inventions are then introduced to the market and implemented in product innovations. The innovation rate describes the product innovations implemented per month.

The service development was also implemented in the model structure (see Figure 3-1). As only gradual differences appear to exist between the innovation processes of products and services (see Kanerva et al. 2006), the development process for services was aligned to that of products. There is a potential of service innovations which the service department fully utilizes over time. It becomes increasingly difficult over time for the firm to extend the knowledge stock about service potentials through the same structure. This knowledge status is described by the stock of service inventions. The services introduced to the market are represented as service innovations and the innovation rate depicts the service innovations per month. If an industrial firm offers services, then there is a possibility, because of the systemic nature (see Busse 2005, Duschek 2002), to carry out improvements or modifications in the service range by means of product innovations.

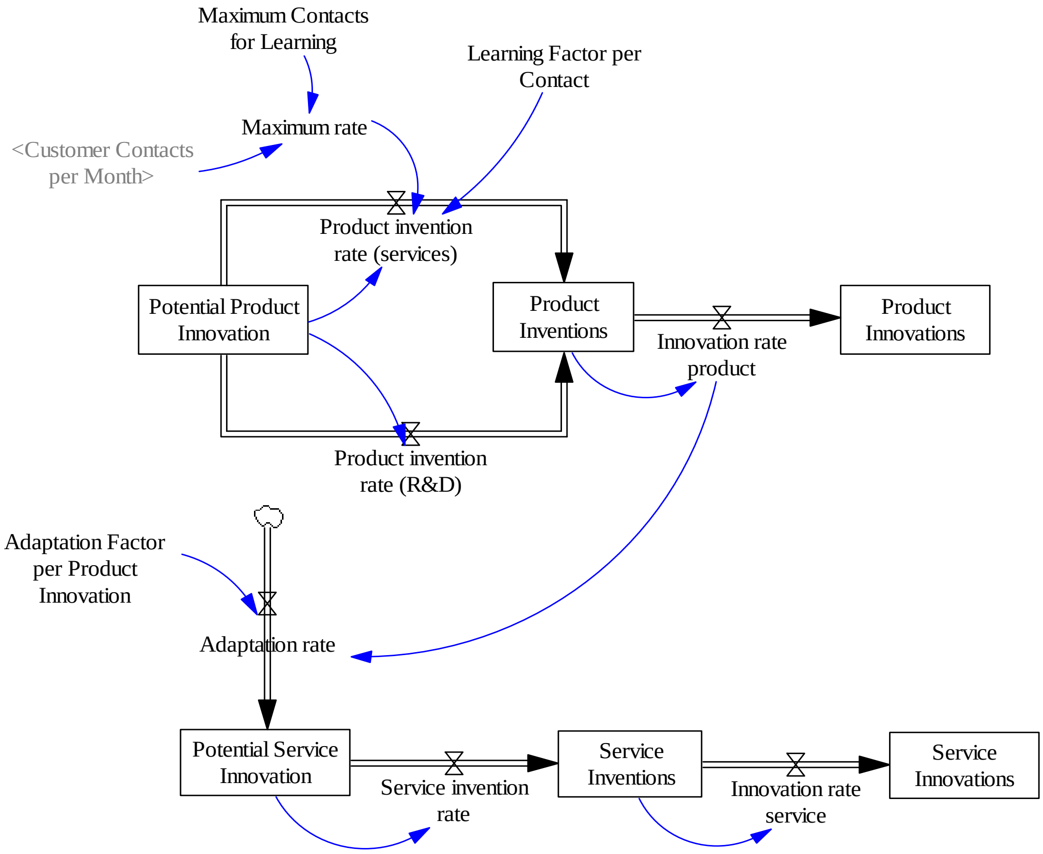

Figure 3-1: Stock and flow diagram for product and service development

By this means, the potential for service innovations can be raised, in contrast to the material product. However, new service innovations are not necessarily generated through the offer of new products. The constant “Adaptation Factor per Product Innovation” describes the ability of companies to recognize the new demand of customers for services, and thus to increase the knowledge stock about improvement possibilities for services. This constant can be varied from 0 per cent (no ability to recognize the service needs), up to 100 per cent (the ability to generate one service innovation exactly from each product innovation).

The third sub-system refers to the diffusion of the product in the market (see Figure 3-2). For this purpose, Bass's diffusion model for demand development was modified which takes repeat purchases into consideration (adopted from Sterman 2000; Bass 1969). A certain customer potential exists at product introduction, which is exhausted over time by the demand. "Customers" describe the client stock and express the company's installed base of industrial products. "Obsolescence" describes the period in which a product ages and must be re-purchased, when the client becomes a potential customer again (see Sterman 2000; Stumpfe 2003). Alpha and beta are factors for describing the diffusion process (see Bass 1969) for initial purchases.

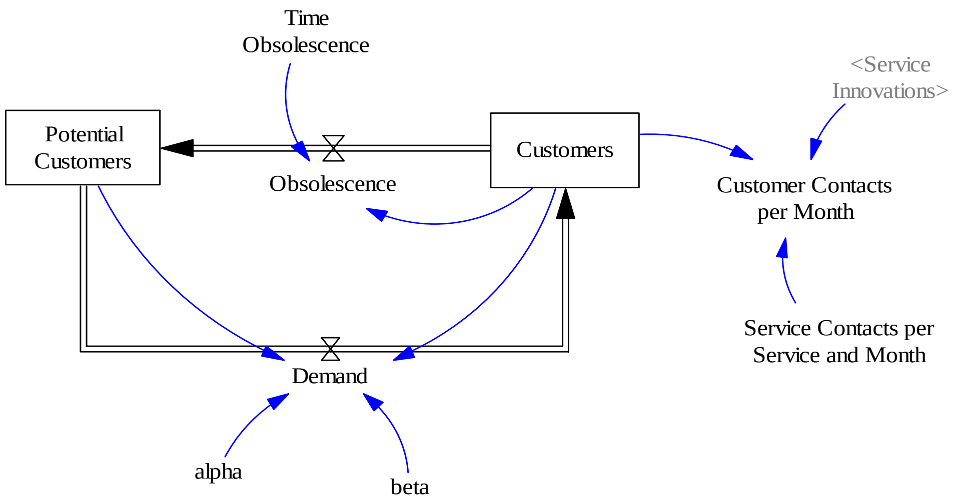

Figure 3-2: Demand development of the product with repeat purchases

From the number of customers we can calculate the number of customer contacts, which results from the sum of services offered (stock of service innovations from Figure 3-1) and the average service contacts per month and client. These service contacts are passed into the information channel for new products (see Figure 3-1). The three sub-systems are already sufficient for a simple model to depict the dynamic hypothesis, carry out simulation runs, and gain first insights.

4 Simulation runs and tests

In order to test the dynamic hypothesis, the study focused on the constants "Learning Factor per Contact" and "Adaptation Factor per product Innovation", as well as their impacts on the innovation rates of products and services. An overview of these two constants as well as the innovation potentials of products and services assumed for this study can be seen in Table 1.

- The "Base" run describes an industrial company without any service offerings. Companies belonging to this type enhance their material products only.
- The run “Service Provider A” illustrates the same company, but generating five service innovations over the life cycle of the product. Moreover, this company is not able to adapt the service offer due to the implementation of product enhancements. Second, the employees conducting the services are not able to learn anything from customer contacts resulting from the service offer.

- Companies belonging to the run “Service provider B” generate 5 service innovations also, but their employees generate knowledge from 20 per cent of all customer contacts resulting from services. Moreover, they are able to adapt the service offer for 20 per cent of all developed product innovations.
- The runs “Impact Learning” and “Impact Adaptation” validate the simulation model, on the one hand, and on the other hand, show what happens under extreme conditions. The run “Impact Diffusion Progress” shows the difference in innovation rates of services and products between various diffusion progresses.

Run	Potential Product Innovation	Potential Service Innovation	Learning Factor per Contact	Adaptation Factor per Prod. Innovation	beta
(1) Base	25	0	0	0	0.1
(2) Service provider A	25	5	0	0	0.1
(3) Service provider B	25	5	20	20	0.1
(4) Impact Learning	25	5	100	0	0.1
(5) Impact Adaptation	25	5	0	100	0.1
(6) Impact Diffusion Progress	25	5	20	20	0.15

Table 1: Overview of the assumed innovation potentials and constants for the simulation runs

All other parameters were fixed for the runs. The graphs containing core information are shown in the following. Other diagrams with additional information are listed in the appendix.

4.1 Results of base runs

The product innovations and the innovation rate of products are illustrated in Table 1 for the base runs. The run “Base” and “Service Provider A” show the same curves for both diagrams. Of course, an industrial company without any service offers is not able to stimulate the circulation of the dynamic hypothesis (see “Base”). But when the innovation rate of products is observed, the typical trend of innovation progress over time can be realized, as described by Utterback/Abernathy (1975). At the beginning, there are high innovation rates and the lower the residual potential becomes, the harder it is to generate innovations for the company.

Almost the same result emerges for the second run. Indeed “Service Provider A” offers services and is able to generate service innovations, but the enterprise is not able to learn from service contacts or to improve the service offer as a result of implemented product innovations. Actually, there is no dynamic interaction between product and service innovations, but both services and products are developed independently of each other. Finally, there are no advantages for this service provider against industrial companies without service offers concerning the interactive innovation progress.

The run “Service Provider B” produces another result, because this enterprise is able to adapt services due to product innovations and to generate knowledge about product improvements as a result of service contacts. This enterprise exceeds the number of 20 product innovations after 64 months, whereas the other runs do not reach this number until 90 months. Actually, there is a time lag of 26 months and consequently a competitive advantage in favour of “Service Provider B”. All in all, this advance of innovation starts in month 40 and remains over the whole observation period of 120 months (see Figure 4-1).

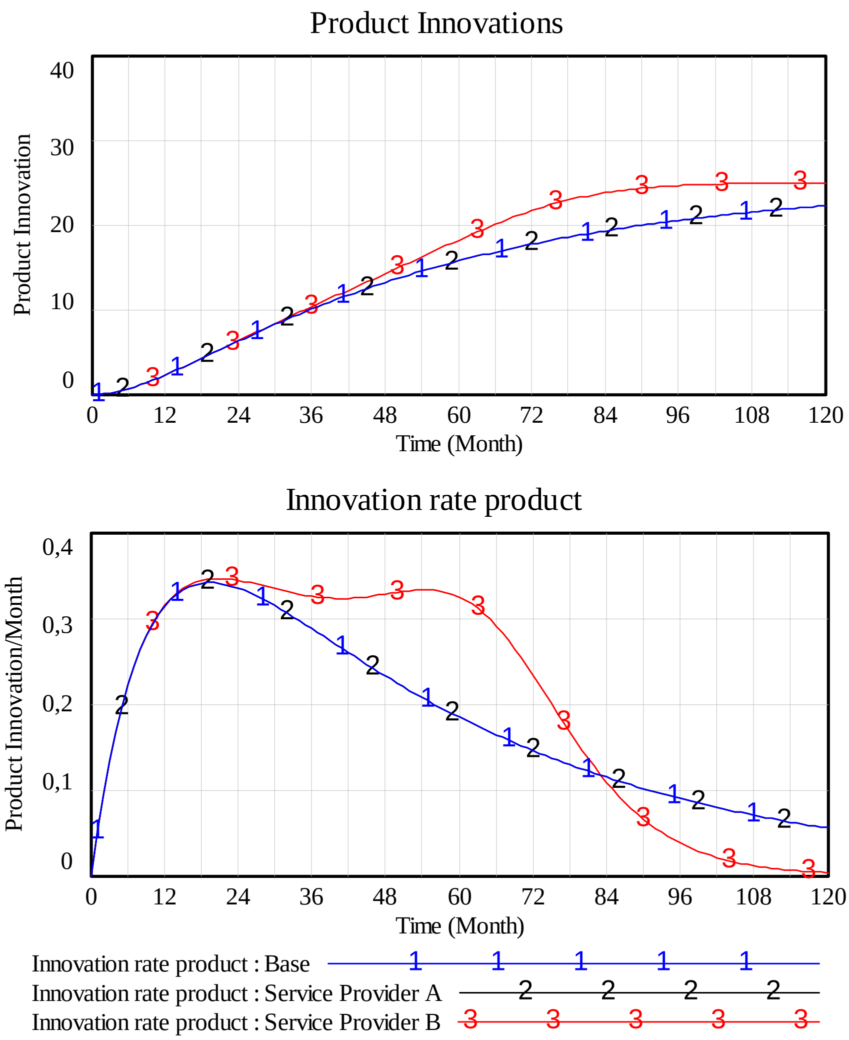

Figure 4-1: Base runs showing product innovations and the innovation rate of products.

In contrast to the other runs, the innovation rate of products does not decrease after 20 months. Due to the learning effect resulting from service contacts, this company is able to keep the innovation rate at a high level and not decrease until 60 months. To sum up, this company is able to tap the product potential much faster and earlier than companies that are not able to learn from service contacts.

The results considering service innovations are illustrated in Figure 4-2. The lines for the “Base” run remain at the zero level, because there are no service offers. But consequently, there are large differences between “Service Provider A” and “Service Provider B”. “Service Provider A” reaches the level of five service innovations only by 90 months. The innovation rate of services decreases already at about 15 months. After 60 months there are almost no kinds of progress concerning service innovations. In contrast to this, enterprises that are able to improve services due to product innovations can deliver much more than only these five innovations. “Service Provider B” already exceeds the number of five service innovations between 40 and 50 months. Moreover, this company generates almost twice the number of innovations than the companies which do not improve their service offers. Regarding the innovation rate of services, the decrease is clearly slower than in the run “Service Provider A”.

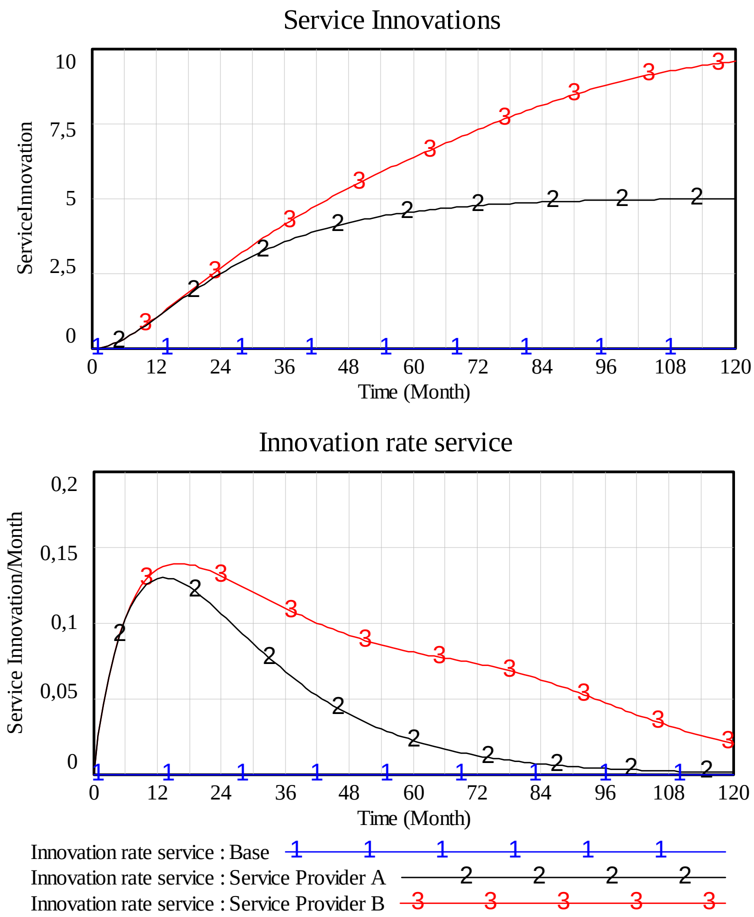

Figure 4-2: Base runs showing service innovations and the innovation rate of services.

Taking a cross view between product and service innovations, it is obvious that there is a peak after 60 months in the innovation rate of products and a lower decrease for the service innovation rate. This peak is the combination of the maximum of the diffusion progress (see demand in Figure 7-1), reaching first the product innovations (due to learning) and afterwards directly service innovations (due to adapting).

4.2 Impacts of learning, adaptation and diffusion progress

The results shown above describe the impacts of innovation processes, differentiated between companies using the interaction of product and service innovations and companies that are not able to use this feedback loop. This section points out the impact of each single factor regarded above.

The first graph shows the innovation rate of the product, including the first three runs discussed above and runs four to six (compare to Table 1). The first finding is that there is no difference between the "Base" run, the run "Service Provider A" and the run "Impact Adaptation". The reason for this is that the capability to improve services due to product innovations has absolutely no impact on product innovations. Furthermore, there are great impacts, if the company is able to discover potentials to improve the product due to service contacts. The result is a permanent increase of the innovation rate in about the 46th month (compare to Figure 4.2-1).

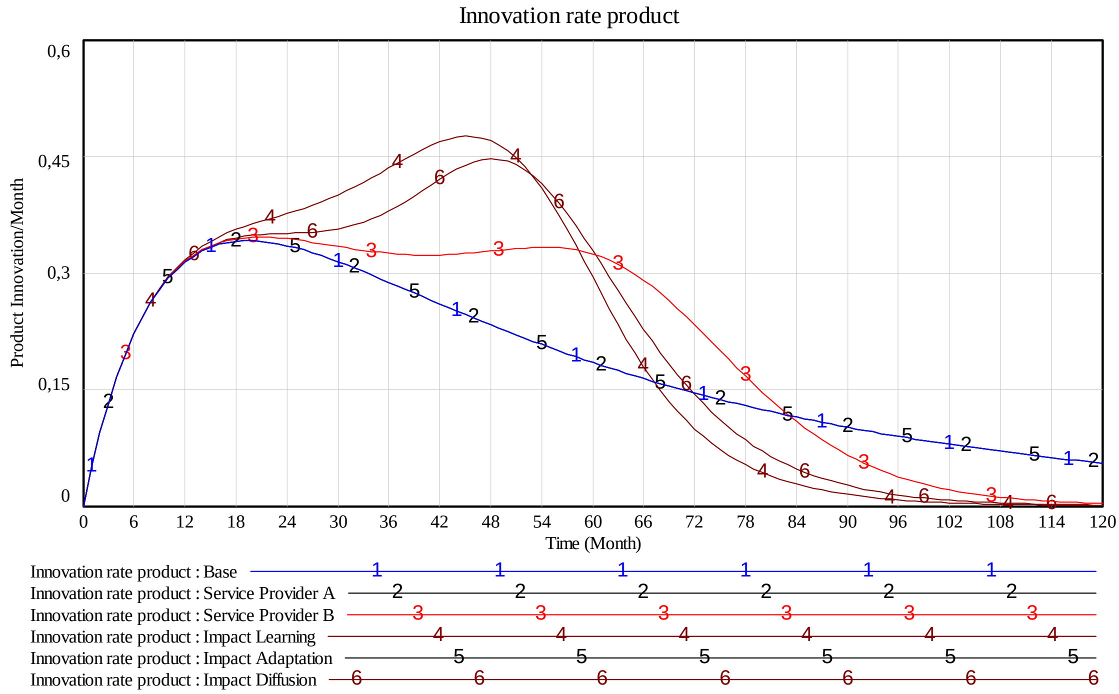

Figure 4.2-1: Innovation rate of products for all runs

The last run follows the impact of diffusion progress on the innovation rate of the product. If there is faster progress (compare to Figure 7-1), there are more customer contacts in early phases and the company is able to learn faster and hence to generate more product innovations in a shorter time. Summing up, the role of diffusion progress is not a subordinate one with regard to the innovation rate of the product.

The second diagram shows the innovation rate for industrial services (compare to Figure 4.2-2). The first three runs were already explained once above. The runs four to six describe the impacts of the three various factors. Consequently, this time there are no impacts on the innovation rate of services for the run “Impact Learning”. The ability to discover potentials for improvements of the product does not affect the number of service innovations. On the other side, there are great impacts due to the capability to adapt services as a result of product innovations. With a percentage rate of 100 per cent, this company would be able to generate exactly one service innovation for each implemented product innovation. This is the reason for the high innovation rate over such a long time for the run “Impact Adaptation”.

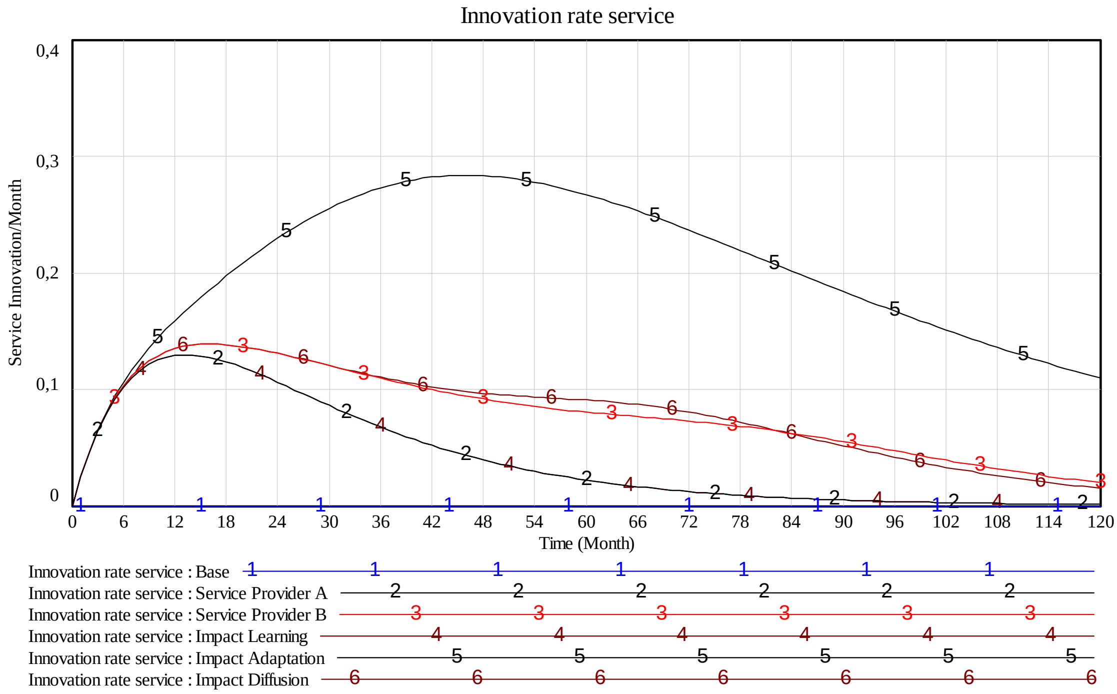

Figure 4.2-2: Innovation rate of services for all runs

With regard to diffusion progress, there is a little difference between the run “Service Provider B” and the run “Impact Diffusion”. Finally, diffusion also has impacts on the innovation rate of services.

5 Conclusions and Outlook

In summing up, it can be stated that a system dynamic model is able to map the discussed dynamic hypotheses derived from the literature. With the help of various simulation runs, we could show that industrial firms that offer additional services related to the core product are in a position to generate higher innovation rates than enterprises that do not offer services. This enables an innovation lead which can lead to competitive advantages. Similarly, product innovations can result in improvements to the services offered.

The interaction triggered off between product and service innovations can also accelerate this cycle. In order, however, to stimulate this interactive innovation process in a targeted manner, industrial firms must be in a position, on the one hand, to generate knowledge through customer contacts via services, and on the other hand, to recognize customer (service) needs resulting from product innovations, and to respond to them in the form of new service offers. If only one of the two necessary processes can be realized, the interactive innovation process comes to a standstill and the cycle stops abruptly/ is broken.

However, this study is only a first approach, based on a simple system dynamic simulation model. Resource limitations were not considered, nor were the strategic decisions of companies taken into account. The model targets only the feasibility of the dynamic hypothesis, with the aim of identifying initial influential factors and pointing out differences in the innovation processes of various firms in the interaction of product and service innovations. This contribution should be regarded as a first approach to further research.

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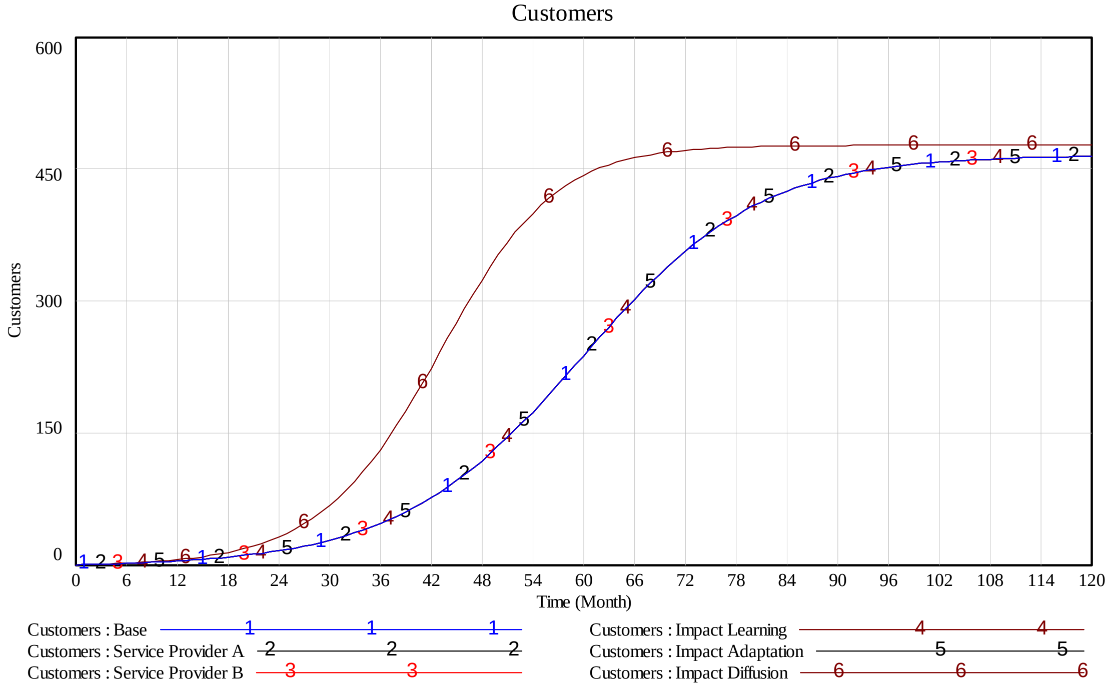
7 Appendix



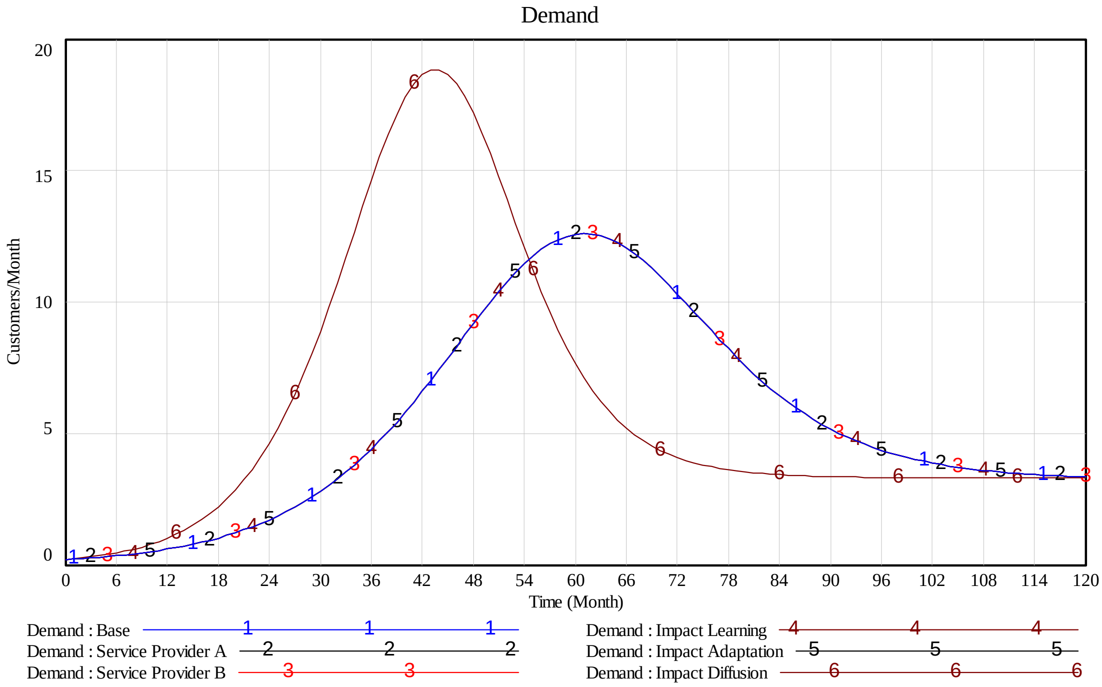


Figure 7-1: Customer and demand behaviour depending on diffusion progress (all runs)

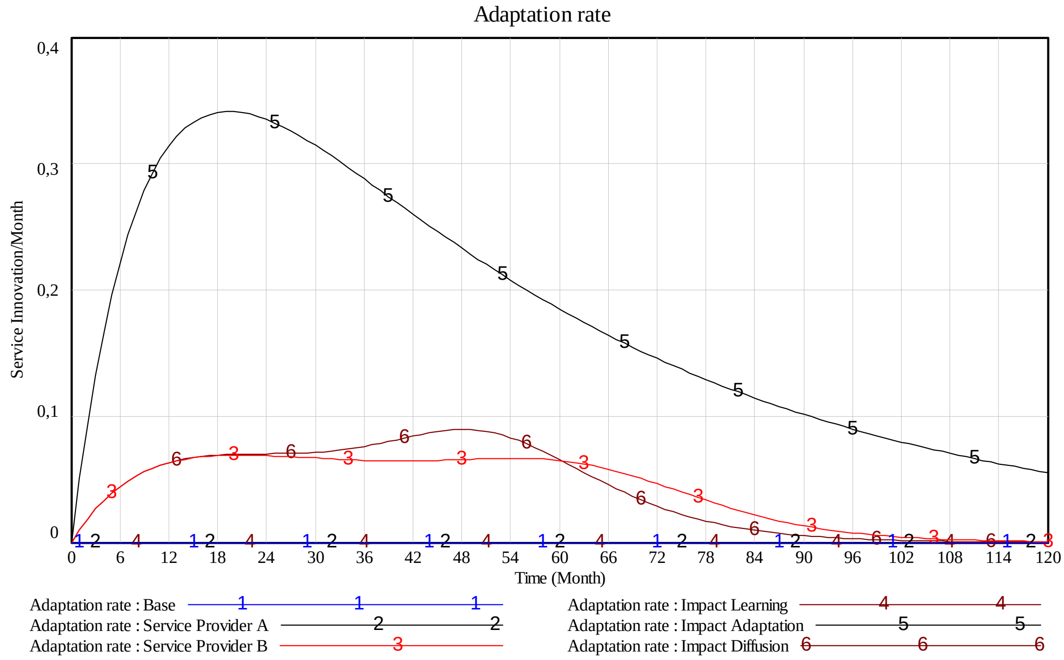


Figure 7-2: Adaptation rate, ability to adapt services due to product innovations (all runs)

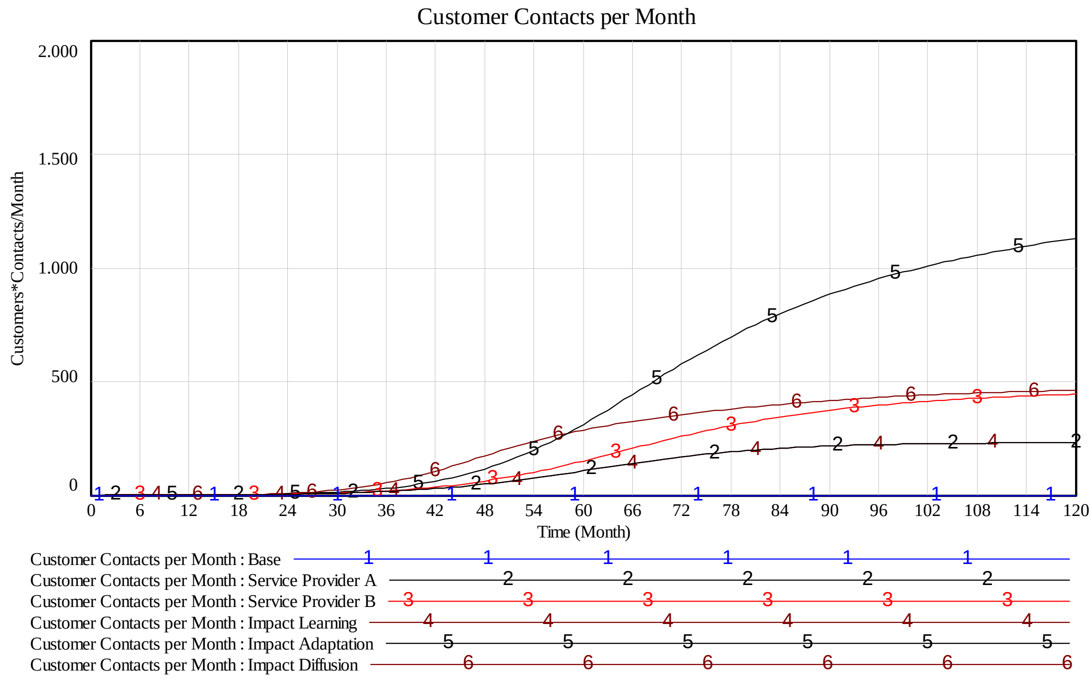


Figure 7-3: Customer contacts due to service offers (all runs)