Linking Innovation and Service Productivity - An analysis of interactive effects in knowledge-intensive business services

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The productivity of services has recently become the subject of intensive research. While most contributions here have focused on developing measurement concepts, so far little is known about the dynamics of productivity in service companies. Because productivity tends to increase if the service delivery process is enhanced and improved, there seems to be a link between incremental service innovations and the productivity of services. Therefore, this article analyzes the interaction of innovations and productivity over time in knowledge-intensive business services (kibs). A simple system dynamics model was constructed to examine these dynamics and interactions over the life cycle of an exemplary knowledge-intensive business service offer. First the system structure is developed using literature analysis. Second, several simulation runs and experiments are conducted, to obtain a deeper understanding of the interactions of service innovations and productivity. The paper closes with findings and conclusions.

System dynamics, knowledge-intensive business services, innovation, productivity

1 Introduction

The productivity of services has recently become an important research. Measuring productivity in knowledge-intensive business services (kibs) seems to be a matter of particular interest (e.g. Biege et al. 2011). While most contributions analyze or develop measurement concepts for these knowledge-intensive business services, little is known about the dynamics of productivity in service companies. Because productivity rises if services are improved, there seems to be a link between incremental service innovations and service productivity. Therefore, this article takes the first step towards analyzing the interactive effects of innovations and the dynamics of productivity using a system dynamics model.

Two research questions seem to be relevant when analyzing the correlations between innovation and productivity in knowledge-intensive business services:

(1) What are the dynamics of productivity in knowledge-intensive business services?
(2) How do service innovations and the productivity of services behave over time and what are their interactive effects?

A small system dynamics model was constructed for the innovation system of knowledge-intensive business services and used to analyze the dynamics and interactions of innovation and productivity over a specific period of time.

The following procedure was chosen to answer the key questions: First of all, a short literature analysis was conducted to identify the interactive effects of innovation and productivity. The findings are used in chapter 2 to construct a system containing stocks and flows which forms the basis of the system dynamics model. In chapter 3, simulation runs and tests are conducted to analyze the impacts of individual factors and to obtain first insights into the system's behavior. The article ends with conclusions regarding the interaction and dynamics of service innovation and service productivity.

2 Innovation and Productivity in Services

To construct a system structure which links innovations and the productivity development of services, the simulation model contains three elements. The first represents innovation processes in knowledge-intensive business services and describes the origin of service innovations over time. The second element stands for the client structure and shows the diffusion progress of an exemplary service offer over time. The last element is a simplified approach using stocks and flows to measure the productivity of knowledge-intensive business services. In following, the three elements and their interconnections are explained in detail.

Innovations in service companies can be classified into two types (e.g. Hipp et al. 2003; Schniering 2009). The first category is defined as "service innovations", involving totally new or significantly new service offers to clients concerning quality or composition (see Schniering 2009; Hipp et al. 2003). The second type, called "process innovations" or also "delivery innovations" (see Hipp et al. 2003 or Miles 1995), concern the introduction of new methods of service production. Particularly this second type seems to have the ability to increase the productivity of services (see e.g. Albach 1989; Schniering 2009). For this reason, innovations in knowledge-intensive business services are also separated using these categories in this analysis. Two different innovation processes seem to exist in companies of the service sector. Finally, both processes together describe how innovations originate in knowledge-intensive business services (see Figure 2-1).

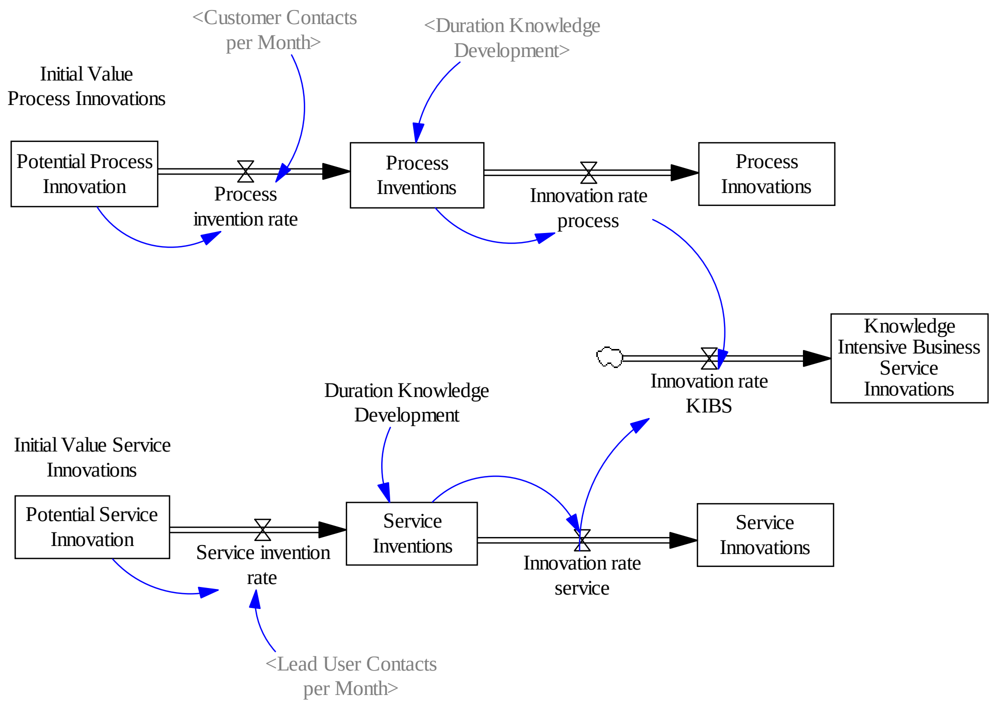

Figure 2-1: System of innovation processes for knowledge-intensive business services.

The innovation system is based on Schumpeter's work. Earlier system dynamics studies dealing with the origin of innovations also made use of Schumpeter's innovation processes (see Schumpeter 1911; Schumpeter 1950) and consequently they are assumed to be helpful for dynamic analysis, too.

Starting from a total innovation potential (service/process innovations), service and process inventions are initially generated by two different sources. While service innovations are mainly generated by information from lead-users (e.g. Hipp et al. 2007), process innovations arise due to information from the market (e.g. Blind et al. 1999). This information flow is stimulated by contacts with customers or lead users and contains feedback loops to the client structure. Over time it becomes increasingly difficult for the firm to further increase its knowledge stock about service potentials. This knowledge status is described by the stock of service inventions. Knowledge development in the time period companies have to generate solutions to identified problems closes the time gap between identifying potentials and implementing solutions or rather innovations. Solutions introduced to the market or implemented in the production process are represented as service innovations or process innovations. The innovation rate of both types depicts the number of innovations per month in knowledge-intensive business services ("Innovation rate KIBS").

The second subsystem containing the client structure can be illustrated using the diffusion model of Bass 1969. This dynamic model for demand development has been used in various previous works in terms of innovation dynamics (see e.g. Lerch 2011; Milling 2002; Milling/Stumpfe 2000; Maier 1993; Milling/Maier 1996). As already described above, both innovation types are stimulated by different sources: lead-users and normal customers. Therefore, two different client structures were incorporated into the model. The first client structure represents the lead-users of the provider and contains a very small number of clients without re-purchases. The second client structure describes all other customers over the life cycle of the service offer and contains a large number of customers and re-purchases. The information flow is stimulated by the number of contacts with lead users/customers per month. These contacts represent information feedback about improvement potentials to the service offer or service production. The innovation potential gradually gets exhausted by this information feedback (see again Figure 2-1). The client structure is shown in the appendix in Figure 6-1, taken from previous studies (e.g. Sterman 2000; Morecroft 2007; Warren 2008) and adapted to lead users (see Figure 6-2).

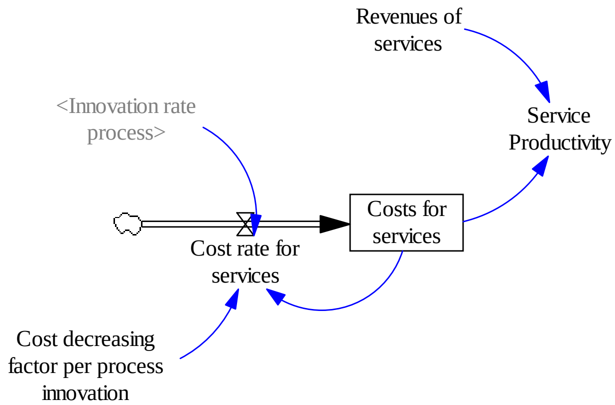

Figure 2-2: Structure of service productivity.

A certain customer potential exists at the beginning, which is exhausted over time by the demand. "Customers" describe the client stock and express the company's installed base. "Obsolescence" describes the period an offer must be re-purchased if the client becomes a potential customer again (see Sterman 2000; Stumpfe 2003). Alpha and beta are factors describing the demand (see Bass 1969) for initial purchases. The structure for lead-users follows the same principle but without re-purchases. Both client structures are shown in Figure 6-1 and Figure 6-2 in the appendix.

The third element contains a simplified structure of stocks and flows for measuring the productivity of services. In general, productivity is measured by the ratio of output and input (see e.g. OECD 2001; Grönroos/Ojasalo 2004; Djellal/Gallouj 2008). For a first analysis it seems helpful to calculate the costs and revenues of the service offer and use them as input and output to observe the development over time. Here, costs represent the input of the service offer and revenues the output. For this simplified dynamic analysis we assume that costs are decreased by every single process innovation ("Cost decreasing factor per process innovation"). The innovation rate of processes is taken from the innovation system shown in Figure 2-1. In contrast to this, revenues are fixed and do not change over time. The development of the ratio of revenues and costs represents the dynamics of productivity in knowledge-intensive business services. The stocks and flows for calculating this factor are shown in Figure 2-2.

3 Results of simulation runs

For a dynamic analysis and a deeper understanding of the system's behaviour, various simulation runs and tests were conducted. Some exemplary runs are shown in the following and interpreted to build first hypotheses. The relevant variables changed for the tests are listed in Table 1.

Run (Figure)	Potential Process Innovations	Potential Service Innovations	Duration Knowledge Development	Cost decreasing factor	beta
Base (all figures)	35	20	6	0.02	0.08
Company A (Fig. 3-3)	20	25	6	0.02	0.08
Company B (Fig. 3-3)	50	15	6	0.02	0.08
		Appendix			
Demand (Fig. 6-3)	35	20	6	0.02	0.12
Knowledge (Fig. 6-4)	35	20	12	0.02	0.08
Decreasing costs (Fig. 6-5)	35	20	6	0.05	0.08

Table 1: Overview of variables and runs

Figure 3-1 shows the base run of the simulation and represents the innovations in knowledge-intensive business services. Line 1 describes the sum of all innovations per month over the life cycle of the service offer containing service innovations (Line 2) and process innovations (Line 3). The major finding of this graph is that two peaks or waves seem to arise during the innovation activities of a service company. The first innovation wave contains mostly service innovations which are sparked very quickly during the first and second year and then decrease over the longer time horizon. These innovations define for instance the dominant design of the service offer, e.g. special features or a kind of basic offer for all customers (transformed from analysis in manufacturing industries, e.g. Utterback/Abernathy 1975). The second wave of innovation comprises mainly process innovations. As already shown above, this type of innovation is closely linked to service productivity. Process innovations occur later and define the productivity level of the delivery process. Consequently, it can be assumed that the higher and longer the second wave of innovation, the higher the productivity level of a service firm.

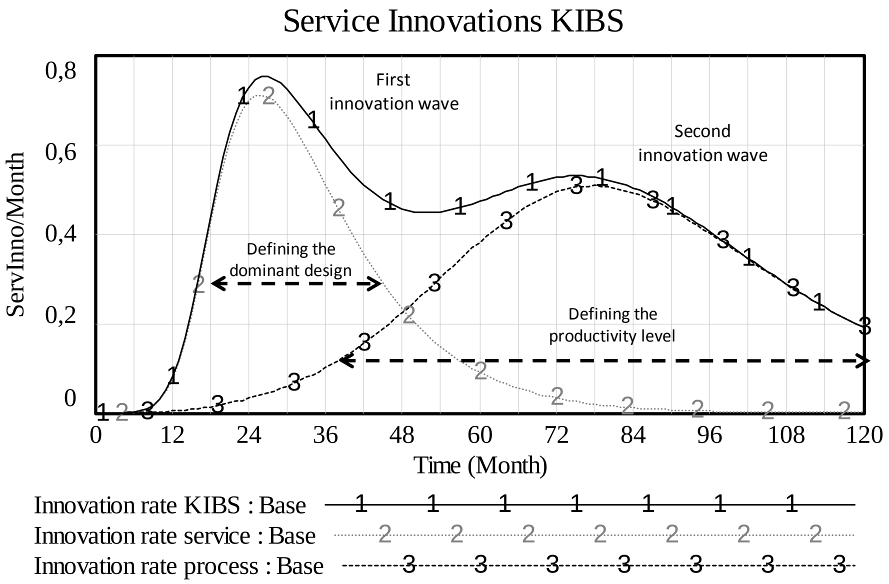

Figure 3-1: The first and second innovation waves in knowledge-intensive business services.

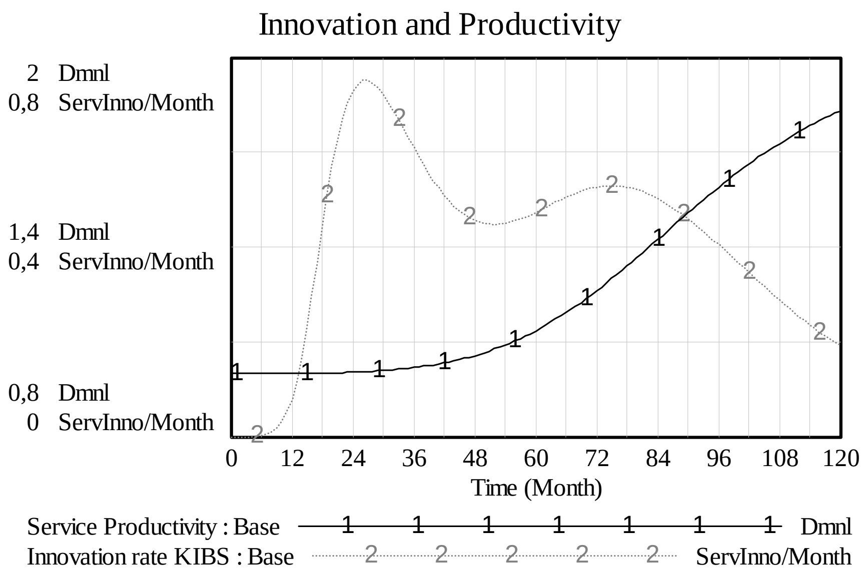

Figure 3-2: Interaction of innovation activities and productivity.

The second diagram shows the link between innovation activities and productivity development in service companies (see Figure 3-2). Line 2 again represents all the implemented innovations per month, while line 1 shows the dynamic behaviour of the productivity level for the exemplary service company. As was expected, the productivity does not change over the first few months because almost no process innovations are generated.

After some time has passed the productivity level is influenced by the second innovation wave and pulled to a higher level. In our case, productivity is still increasing at the end of the life cycle and has not yet reached its limit. Moreover, the productivity curve seems to follow an s-shaped growth and moves closes to the limit of the productivity level over time. Although this level is unknown at the beginning of the life cycle, it is then defined by the implemented process innovations. This graph clearly shows the dynamics and interaction between innovation activities and the productivity of services.

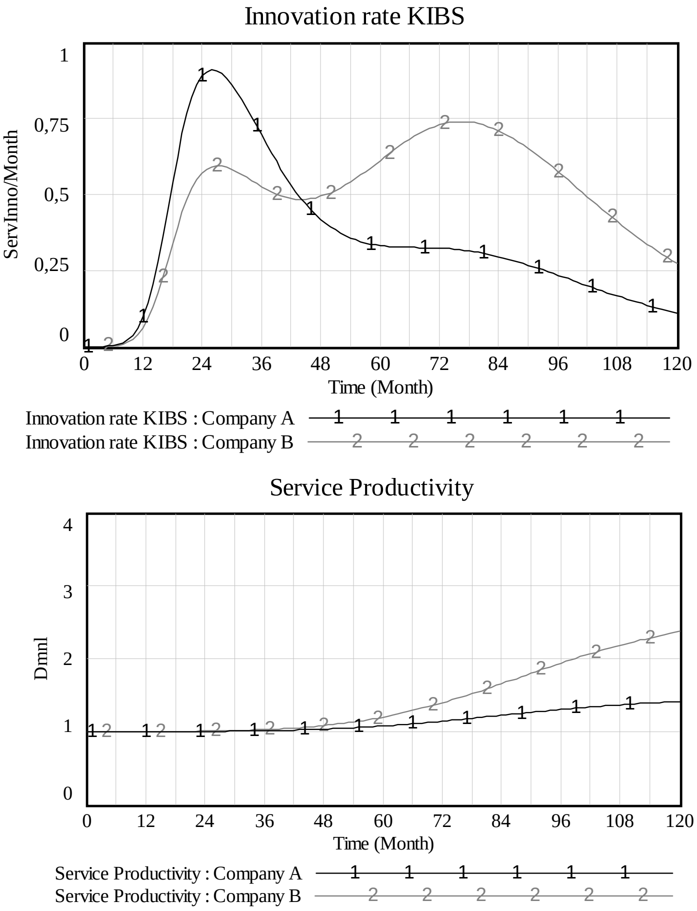

Figure 3-3: Two exemplary companies; link between innovation activities and productivity dynamics.

The third and final diagram shows the evolution of innovation and productivity in two exemplary companies (see graph in Figure 3-3). The first company (Company A) implements more service innovations than company B. Consequently, the innovation activities of company B are higher at earlier stages than those of company A. Comparing the productivity development of the firms shows that there are no impacts on productivity resulting from the first innovation wave.

In contrast to this, the second wave of innovation of company B is much higher than that of company A. This means that company B should reach a much higher productivity level than company A. This effect is shown in the lower part of Figure 3-3. As these simulations show, the productivity of company B rises much faster during the second half of the service life cycle. Due to the higher number of implemented process innovations, the limit of the productivity level is higher, too. The interactive effect of productivity and the second innovation wave can be shown using both diagrams.

4 Conclusions

This paper takes a first step towards analysing the interactive effects of service innovations and the productivity of services. A system dynamics model was developed, which reproduces the system structure in a very simplified way but is able to provide first insights into the system's behaviour. By means of tests and experiments it was possible to develop first hypotheses about the dynamics of productivity. First, there seem to be two waves of innovation activity over the life cycle of knowledge-intensive business service offers. While the first wave has no impacts on service productivity, the second one pulls productivity to higher levels, which are linked to the implemented process innovations. Moreover, productivity follows an s-shaped curve and is slowed by a natural limit which describes the productivity level of a service company.

However, this dynamic analysis is just a first step based on simplified systemic structures. Strategic decisions were not considered and the productivity of services is only measured by costs and revenues. Moreover, the sources of innovation are probably much more complex in knowledge-intensive business services than those regarded here. The simulation model only targets on first findings and insights into the system's behaviour and should be regarded as providing an initial framework for further studies.

5 References

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6 Appendix

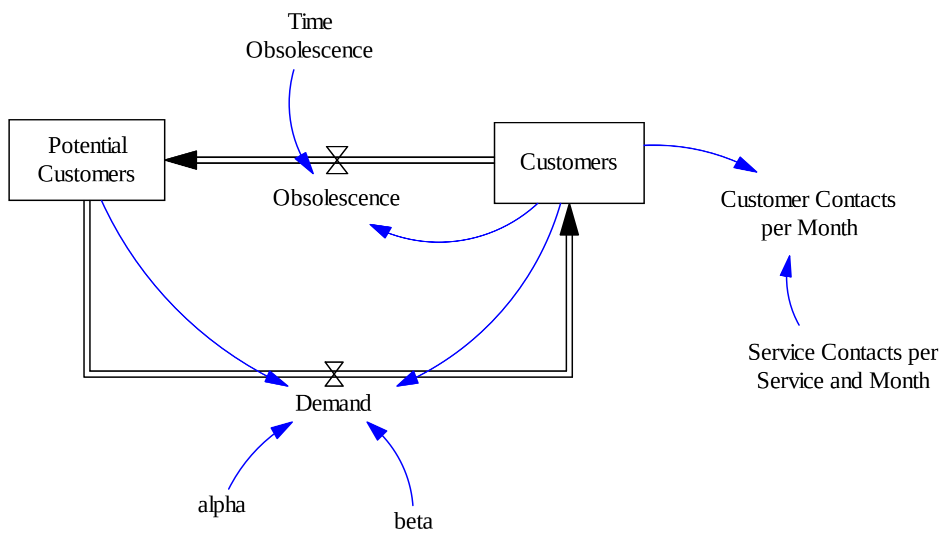

Figure 6-1: System structure of customers, including re-purchases.

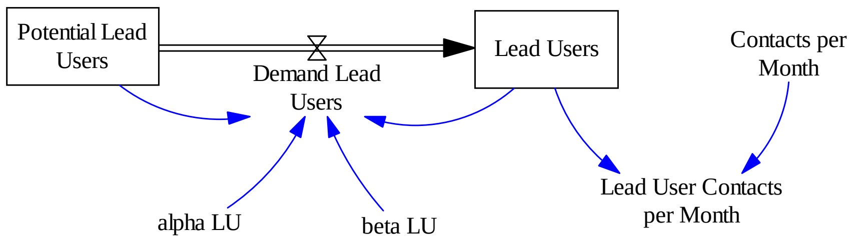

Figure 6-2: System structure of lead users, without re-purchases.

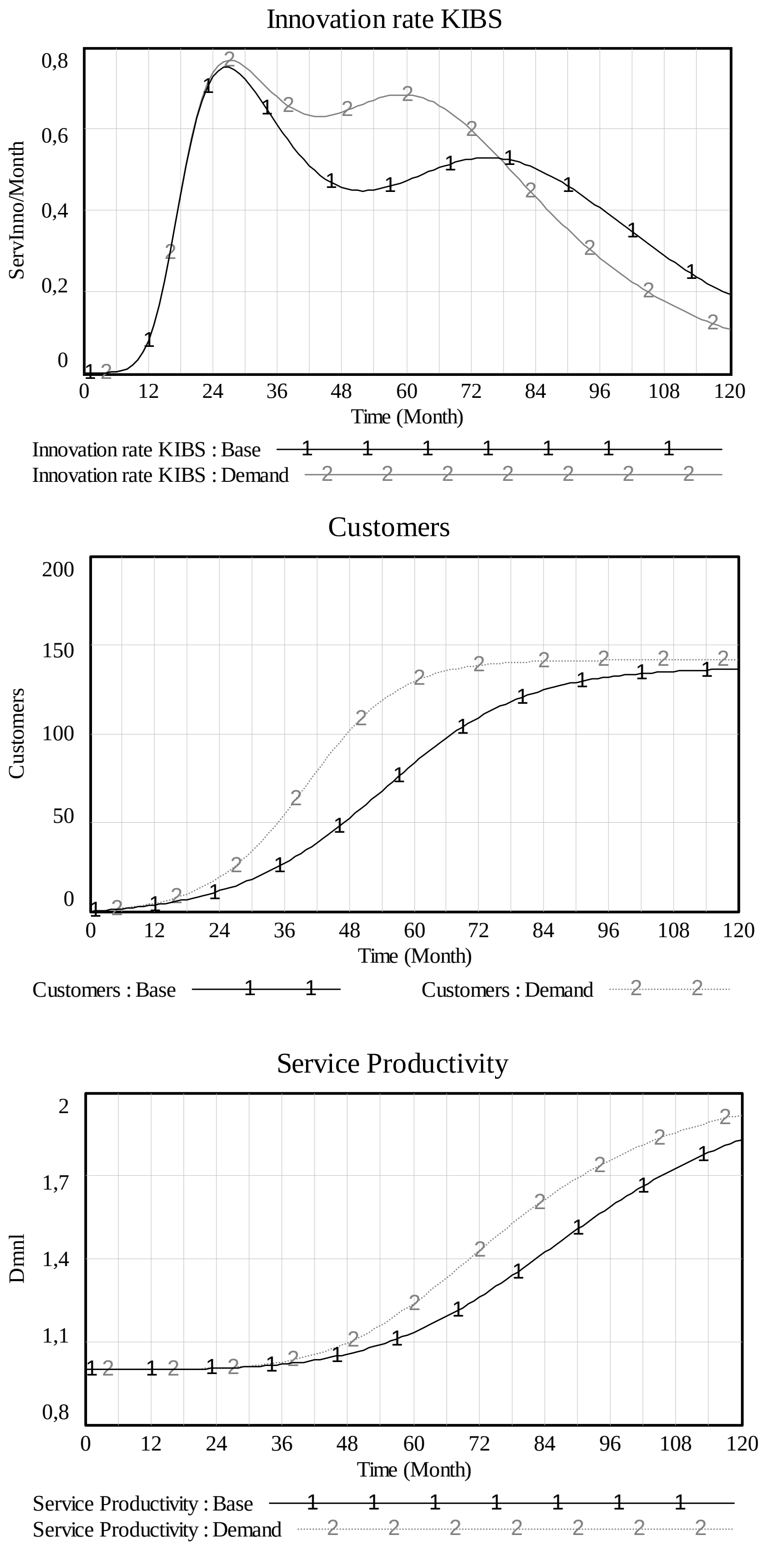

Figure 6-3: Innovation activities, customers and service productivity depending on beta.

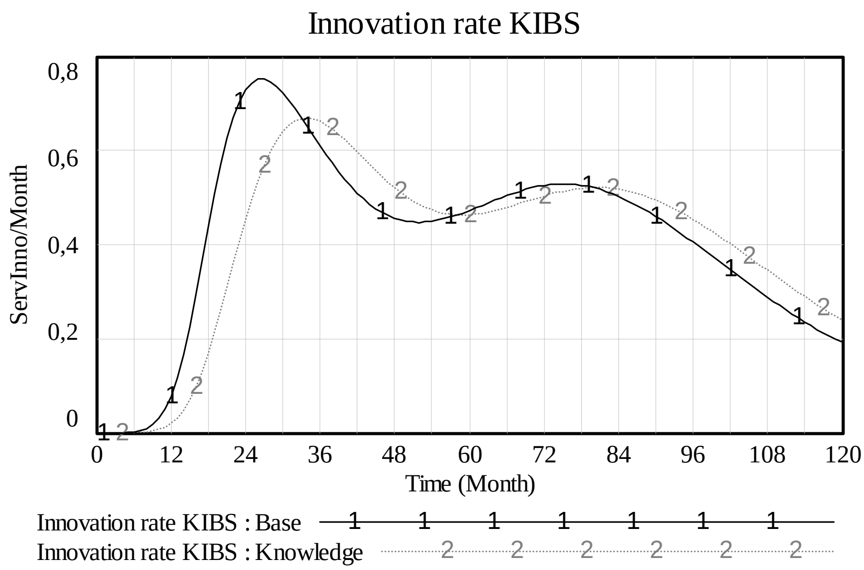

Figure 6-4: Innovation activities depending on the duration of knowledge development.

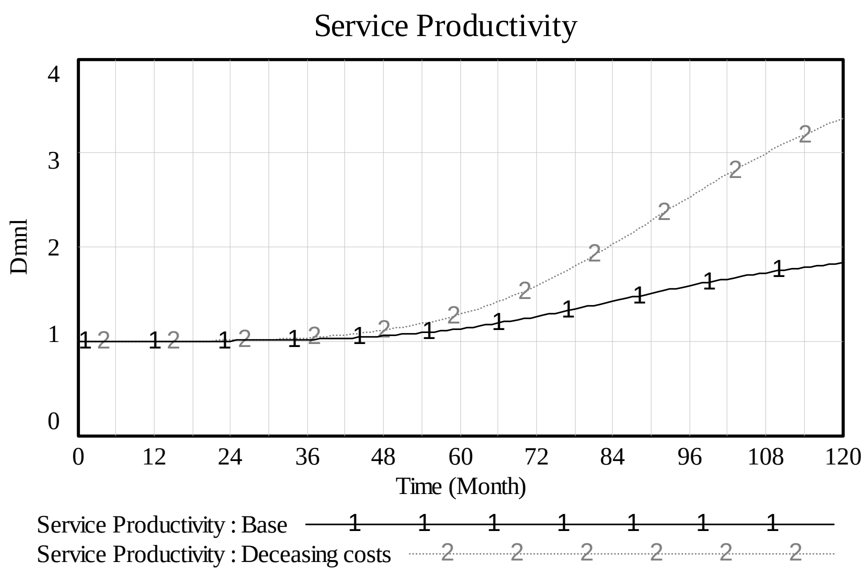

Figure 6-5: Service Productivity depending on the cost decreasing factor.

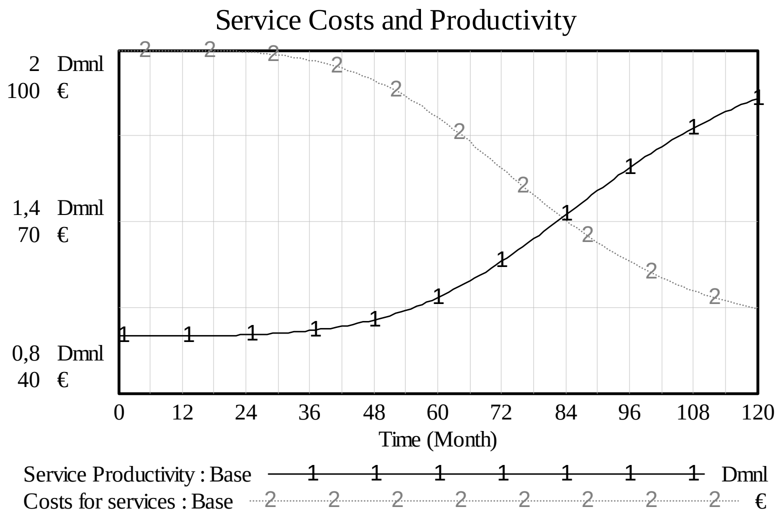

Figure 6-6: Linkage of service costs and service productivity.

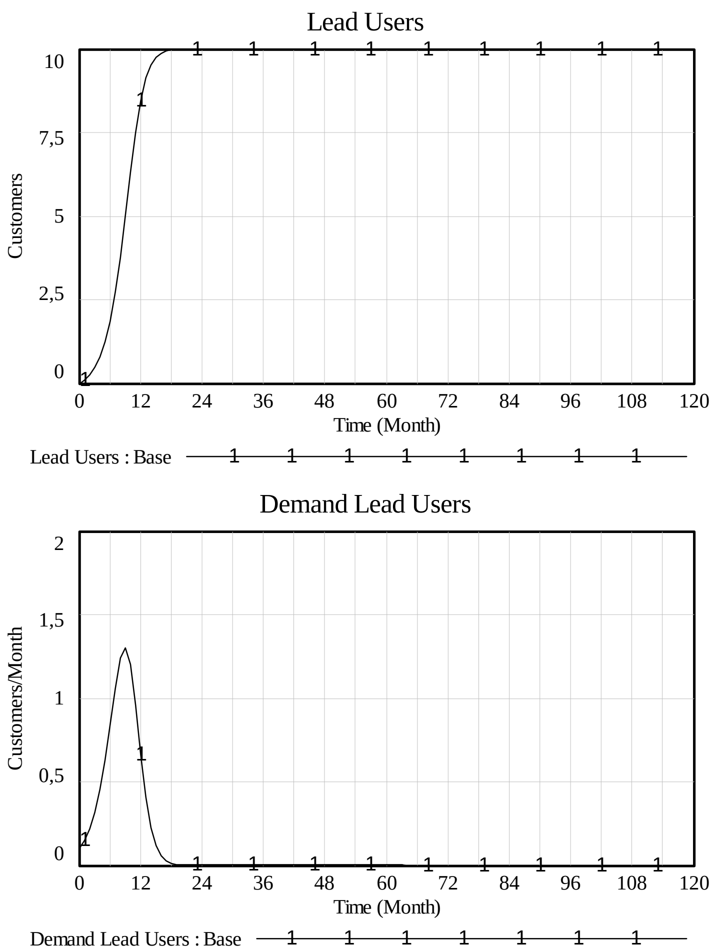

Figure 6-7: Lead users.