Discussion Paper No. 10-100

Enterprise Software and Service Innovation: Standardization versus Customization

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Non-Technical Summary

Enterprise software systems support service firms in planning, supporting and managing business processes. In general, these software packages can be categorized in standardized generic applications, software systems designed to fit one particular business sector or completely customized enterprise software developed for a single firm. Sector specific enterprise software is expected to facilitate the knowledge handling, storing and accumulation especially by presentating information in an adequate manner. In addition to the benefits mentioned, a firm using customized enterprise software can also incorporate long-term experience and knowledge in the software application, making it perfectly suitable for fulfilling all requirements and needs for its specific business. By taking part in or completely shaping the design of the software, a firm using customized software may build up its own IT know-how, resulting in an optimization of business processes and time managment. These optimizations allow service firms focusing on the design of new services. Taking all the benefits together, the use of customized enterprise software systems is expected to support innovation in the service sector rather than the use of sector specific enterprise software.

This paper analyzes the relationship between the use of sector specific enterprise software and service innovation as well as the relationship between the use of customized enterprise software and service innovation. The analysis is based on a knowledge production function estimated by a probit model. The basis of the analysis is a dataset consisting of German service firms that provide information and communication services and knowledge-intensive services.

The results indicate no relationship between the use of sector specific enterprise software and service innovation. On the other hand, the use of customized enterprise software is related to service innovation in a positive and significant way. Taking former innovative activities into account, the analysis suggests that the causality runs from the use of customized enterprise software to service innovation. The positive impact of customized enterprise software on service innovation stays robust among different specifications.

Das Wichtigste in Kürze

Unternehmenssoftware dient der Planung, Unterstützung und Steuerung betrieblicher Prozesse. Im Allgemeinen unterscheidet man bei Unternehmenssoftware zwischen Standardsoftware, branchenspezifischer Software (Branchensoftware) und unternehmensspezifischer Software (Individualsoftware). Branchensoftware dient der Bearbeitung, Speicherung und Bildung von Wissen sowie zur Aufbereitung und Darstellung von Informationen und ist gleichzeitig essentiell für die Bereitstellung von Dienstleistungen in Branchen wie zum Beispiel Architektur oder Steuerberatung. Zusätzlich zu diesen Vorteilen bietet hingegen Individualsoftware den Unternehmen die Möglichkeit, langfristige Erfahrungen und Wissen in die Entwicklung der Software einzubinden und sie dadurch optimal auf die Bedürfnisse eines Unternehmens zuzuschneiden. Darüber hinaus haben Unternehmen, die Individualsoftware nutzen, die Möglichkeit, durch die aktive Teilnahme am Herstellungsprozess der Software, eigenes IT-Fachwissen aufzubauen, das durch die daraus resultierende Optimierung der betrieblichen Prozesse und des Zeitmanagements eine verstärkte Fokussierung auf die Entwicklung neuer Dienstleistungen ermöglicht. Aufgrund dieser Vorteile hat der Einsatz von Individualsoftware im Vergleich zum Einsatz von Branchensoftware eher das Potenzial, die Innovationstätigkeit von Unternehmen zu unterstützen.

Diese Studie untersucht den Zusammenhang zwischen dem Einsatz von Branchensoftware bzw. Individualsoftware und der Innovationstätigkeit im Dienstleistungssektor. Dabei wird eine Wissensproduktionsfunktion mit Hilfe eines Probit-Modells geschätzt. Als Datenbasis fungieren Daten von deutschen Informations- und Kommunikationsdienstleistern und wissensintensiven Dienstleistern.

Die empirische Untersuchung zeigt keinen Zusammenhang zwischen dem Einsatz von Branchensoftware und der Innovationstätigkeit im Dienstleistungssektor. Im Gegensatz dazu weist der Einsatz von Individualsoftware einen positiven und signifikanten Zusammenhang zu Innovationen im Dienstleistungssektor auf. Unter Berücksichtigung vorhergehender Innovationsaktivitäten der Unternehmen deutet die Analyse auf eine Kausalität hin, die von dem Einsatz von Individualsoftware zu Dienstleistungsinnovationen verläuft. Die Ergebnisse sind über verschiedene Modellspezifikationen hinweg robust.

Enterprise Software and Service Innovation: Standardization versus Customization*

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Abstract

This paper analyzes the relationship between service innovation and different types of enterprise software systems, i.e. standardized enterprise software designed to fit one certain business sector and enterprise software specifically customized for a single firm. Using firm-level data of a survey among ICT service providers and knowledge-intensive service providers in Germany, this is the first paper empirically analyzing whether both types of enterprise software foster innovation in the service sector. The analysis is based on a knowledge production function. The results reveal that there is no relationship between sector specific enterprise software and innovation activity while customized enterprise software is possibly related to the probability of service innovation. The results stay robust if former innovation activity and general openness to new technologies are controlled for.

Keywords: enterprise systems, service innovation, customized enterprise software, sector specific enterprise software
JEL-Classification: L10, M20, O31

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1 Introduction

A large range of enterprise software products nowadays supports day-to-day business operations, controls manufacturing plants, schedules services or facilitates decision-making. The purpose of these software applications is, in general, to automate operations reaching from supply management, inventory control or sales force automation to almost any other data-oriented management process. Especially in many frontier fields like semiconductors, biotechnology, information and telecommunication or other knowledge-intensive industry branches, employees might be able to observe, measure or even envision any phenomena only by using special enterprise software applications. SAP, the largest global enterprise software vendor, estimates the adressable market for enterprise software applications to be roughly $ 110 billion in 2010 (SAP 2010).

The range of enterprise software packages is wide with various definitions for the category "enterprise software". One of them covers simply any software application used in the firm while another classification understands enterprise software as a set of packaged application software modules with an integrated architecture, which can be used by organizations as their primary engine for integrating data, processes and information technology, in real time, across internal and external value chains (Shang and Seddon 2002). As standard office packages, email clients and generic accessory programs like calculators or editors are not intended to sharpen the firms' business or management processes as they can be used not only by firms but also by private households, we stick to the popular interpretation of enterprise software as company-wide suites of business software devoted to particular business processes integrated across the value chain (Aral et al. 2006), e.g. product and financial management or graphical visualizations and programming in scientific projects. This classification excludes all standard software also available for private use and focuses on specific business software only available for firms.

Overall, enterprise software can be categorized in three types as users distinguish between generic applications like an enterprise resource planning system purchased in standardized form from the vendor[1], software systems or special modules specifically designed to fit one business sector[2] or completely customized enterprise software packages devel-

[1]E.g. SAP Business One or Oracle E-Business Suite.

[2]Examples for sector specific enterprise software contain computer aided design or manufacturing programs, e.g., solutions offered from Sage.

oped for a single firm in particular and adopted to its specific needs[3]. Thus, customized enterprise software systems are usually unique systems.

Offering operational integration, improved data management and advanced knowledge processing for the entire organization, all kinds of enterprise software could, in general, be expected to improve a firm's innovation activity. However, there are essential differences between different types of enterprise software that might lead to different impacts on the innovation performance of service firms. Business specific software is a standard working tool for some firms as it facilitates the knowledge handling, storing and accumulation especially by presenting information in an adequate manner but is not necessarily intended to shape the innovation process, as it has been in use for a long time and would have generated a potential impact earlier. Thus, we carefully expect as a first hypothesis that sector specific enterprise software has no impact on the innovation performance of service firms. Nevertheless, the mentioned benefits of sector specific software can be expected to turn out larger if customized enterprise software is employed as this kind of software is able to picture business processes and organizational structures in the focused industry perfectly. This software can be developed, shaped and updated according to specific firm knowledge, experience and needs, making it perfectly suitable for fulfilling all requirements for its specific business with shortened reaction times to any given market situation. Therefore, our second hypothesis implies that customized enterprise software might foster service innovation if it is properly developed.

Although the usage of information and communication technology (ICT) applications in general is suspected to enhance firms' innovative activity (Hempell and Zwick 2008; Brynjolfsson and Saunders 2010), the potential impact of sector specific or completely customized enterprise software on innovational performance in particular is still not investigated. The literature in this field is scarce, offering only a few studies which examine the benefits of enterprise software for innovation activity, see e.g. Shang and Seddon (2002). Empirical evidence is even scarcer, provided from Engelstätter (2009) who pictures the impact of three most common generic enterprise systems on firms' ability to realize process and product innovations. Therefore, the current study aims at filling this gap by providing the first empirical evidence of the impact of business sector specific or customized enterprise software on service firms' innovative performance.

[3]Examples here are completely designed software solutions like applications from firms as, for instance, Supremistic or Jay Technologies Inc. In addition, firms could also augment generic solutions like SAP packages with custom-made modules.

We employ a knowledge production function as analytical framework for our empirical analysis. Our study relies on a unique database consisting of 335 German firms from ICT and knowledge-intensive service sectors. The service sector differs from the manufacturing sector with respect to its products and their production and thus with regard to the innovative behavior (Gallouj and Weinstein 1997). Moreover protecting services by patents is difficult due to their intangible nature (Miles 2005, 2008). Although it might be difficult to measure innovation in the service sector as service firms might have difficulties distinguishing between service, process or organizational innovation.

Based on a probit approach, the results confirm that ICT and knowledge-intensive service firms using sector specific enterprise software do not have a higher probability to realize service innovations. In contrast, service firms relying on customized enterprise software exhibit a higher probability to realize service innovations compared to firms not using customized software packages or not using enterprise software at all. These results stay robust to many specifications controlling for several sources of firm heterogeneity like size, age, workforce structure, competitive situation, internal research and development (R & D) and former innovational experience.

The paper proceeds as follows: Section 2 presents the methodological framework. Section 3 introduces the dataset. The estimation procedure is derived in section 4 and section 5 presents the estimation results. Section 6 concludes.

2 Methodological and Theoretical Framework

2.1 Service Innovations in General

Although innovations are generated and realized in services as well as in manufacturing, the analysis and measurement of innovation in service firms turns out to be difficult. The nature of services complicates the use of traditional economic measurements as services are very heterogeneous due to features like intangibility, interactivity and coterminality (Gallouj and Weinstein 1997). Precisely, services turn out to be intangible, because they are hard to store or transport and can sometimes not even be displayed to a customer in advance (Hipp and Grupp 2005). Potential interactivity is constituted in high communication and coordination needs between client and supplier as in most cases both have to be present for the transaction. The coterminality captures the fact that services are often produced and consumed at the same place and time. Accordingly, service innovation might focus exclusively on these three typical features (Miles 2005, 2008), which makes the distinction between product, process and organizational innovations in service sectors difficult and might result in other characteristics driving service innovations compared to R & D-based innovations in manufacturing. Moreover, the protection of services by patents is difficult due to the intangibility of services and their possible imitation.

For service innovation, key elements are, in particular, internal knowledge within the firm and its employees and the external network of the firm including customers and other businesses (Sundbo 1997). Human capital, especially personal skills like experience or extensive customer contact, and knowledge about markets, customer habits and tastes are important for realizing innovations in a service company (Meyer 2010). In addition, information sources like customers and suppliers of equipment can provide essential clues for service enhancement and advancement. Exploring the determinants of service innovation, there is various empirical evidence[4]. This literature mostly supports the hypothesis that service innovations are mostly driven by these mentioned "softer" inputs[5].

In general, many innovations in the service sector use technology development, like, e.g., enhanced ICT components, merely as means and incentive provider for creating new and improving existing products, services and processes rather than just offering technological progress (Hipp and Grupp 2005). This leads to two approaches to analyze the relation between ICT and service innovations. The first one interprets the introduction of technical equipment or ICT directly as a service innovation or at least as a starting point for it[6]. The second group of studies, however, deals with non-technical, service-oriented innovation (Meyer 2010). Analyzing the relationship between ICT-use, measured by enterprise software in this case, and service innovation, the current study takes on the second approach as ICT is not purely meant and adopted to provide already established services. In contrast, ICT is intended to improve and enhance knowledge processing as

[4] A majority of studies on service innovation focuses on knowledge-intensive business services (KIBS), see, e.g., Leiponen (2005) for a review. The current analysis employs data from knowledge-intensive services as well as from ICT-service firms not aiming exclusively at KIBS-literature.

[5] See for example Koch and Strotmann (2006), Schibany et al. (2007), Arvanitis (2008) and Love et al. (2010).

[6] See for example Licht and Moch (1999), Evangelista (2000) or Freel (2006).

well as the connections of the information sources needed for service innovations and might, accordingly, positively impact innovational performance.

2.2 Enterprise Software and Service Innovations

Enterprise software, in particular, might impact the firms' innovation activity through different channels, directly based on the benefits provided or indirectly as the software might foster introducing organizational enhancements, thereby improving the innovation process. In general, enterprise software can be roughly categorized in three types: generic applications, business sector specific software packages and lastly software specifically designed or customized for a single firm. Possible impacts of unspecific generic enterprise software systems, like, e.g., enterprise resource planning, on innovation and firm performance are already covered in the literature[7]. The potential impacts of sector specific or customized enterprise software, however, are missing completely at the moment.

Concerning direct effects, business sector specific enterprise software, whether employed as a module enhancing a generic system or a standalone package, is expected to facilitate the knowledge handling, storing and accumulation. Offering and presenting information in an adequate manner and providing frequently updated real-time databases, sector specific software might function as a "softer" source of innovation according to Tether (2005) and can be expected to improve service innovations. However, some industry branches like e.g. biotechnology, semiconductors or architects need sector specific enterprise software packages like computer aided architecture or manufacturing to complete even the simplest business tasks. In this case, sector specific software can be viewed as a necessary working tool which is not associated with innovation and not intended to shape the innovation process. Therefore, it may also be the case that this kind of software has no impact on firm's innovative performance at all. As business sector specific software is a standard working tool for some firms, a firm will obtain and use it as soon as possible, mitigating any impact on innovative performance as the software has been in use for a long time already and would have generated a potential impact much earlier. Having this opposed expectations in mind, we propose a careful first hypothesis:

[7]See for example Hitt et al. (2002), Aral et al. (2006), Engelstätter (2009).

H1: The usage of business sector specific enterprise software does not foster firms' innovation performance.

If a firm instead or additionally uses enterprise software, which is specifically designed for the own company, all the potential benefits mentioned due to enhanced knowledge processing can even be expected to increase. Having influence on the development of this software, a firm can incorporate long-term experience and knowledge in the software application, making it perfectly suitable for fulfilling all requirements for their specific business with shortened reactions times to any given market requirement. Influencing the software development turns out to be especially useful for firms in the service sector where firms face a high degree of heterogeneity as mentioned above. Being able to construct and shape the software in a way that includes and reflects all needed business processes and tasks, a service firm might be able to quickly deliver information where it is needed, possibly showing room and edges for service innovations. In addition, some new services might only be offered if the firm has access to special software tools and components only available if developed specifically for the firm. In that case, the software might be used as distribution channel for the service or even be needed to realize it. Besides knowledge processing and strengthening connections of information sources, customized enterprise software could equip the firm with forecasting instruments enabling it to check potential benefits and costs of innovations ahead of time. If properly developed, completely customized enterprise software optimized for a specific firm should be able to change the innovation process by completely integrating, merging or eliminating many formerly discrete innovation steps. Additionally, by taking part in or completely shaping the design of the software, a firm may build up its own IT know-how, possibly opening up additional sources for service innovations, especially for ICT-service providers or software programming firms. Combining all these benefits together, we hypothise

H2: Enterprise software specifically designed for a firm will positively impact firm's innovation performance.

Gronau (2010) mentions a lack of initiative and disposition for problem solving and innovation by firms using standardized enterprise software systems compared to firms using customized enterprise software systems. The employees using standardized enterprise software have no opportunity to make own decisions or to act independently. This leads to inferior organization structures in contrast to those resulting from the use of customized enterprise software. As sector specific enterprise software also belongs to the category of standardized enterprise software systems for certain sectors, this conclusion supports our hypotheses.

Besides these direct effects, enterprise software in general might also indirectly increase innovation activity as the software applications may help to realize some organizational enhancements which have been proven to facilitate the generation of more innovations. Thus, Tsai (2001) proclaims that business units become more innovative once they reach a more centralized network position that allows them to retrieve new knowledge generated by other units and also necessary information from them faster. Business sector specific enterprise software rightly fits into this context as the software applications advance the intern network and knowledge processing capabilities of the firm, e.g., by providing a centralized database with access for all employees and business units, fastening connections between them. Additionally, customized software can be expected to picture and functionalize the adequate organizational structure of the utilizing firm, enhancing the firms' communication ways. With communication between employees and business units accelerated and broadened in this way, the innovation activity of the firm might, according to Tsai (2001), also increase. Criscuolo et al. (2005) argue that firms generate more innovations with established upstream/downstream contacts to suppliers and customers. This relation holds especially for service innovations as customers and suppliers can be providers of essential clues and ideas for enhancement and advancement of services. Roper et al. (2006) even support this argument as they stress the high value of backwards and horizontal knowledge linkages for innovations. Facilitating not only firms' intern communication, enterprise software also offers applications to enhance the communication structure outside the boundary of the firm, making maintaining current and generating new contracts with suppliers and customers far easier, especially if the firms employ customized software with specifically developed components for communication, like customized or modified customer or supplier relationship management systems. Consequently, firms with enterprise software in use have access to a large pool of knowledge, which will, according to Criscuolo et al. (2005) and Roper et al. (2006), be helpful in creating more innovations.

3 Description of Data

The data we use in this study is taken from the quarterly business survey among the "service providers of the information society" conducted by the Centre for European Economic Research (ZEW) in cooperation with the credit rating agency Creditreform. The sector "service providers of the information society" comprises nine sectors, thereof three of information and communication services sectors and six knowledge-intensive services sectors[8]. Every quarter, a one-page questionnaire is sent to about 4.000 mostly small and medium-sized companies. The sample is stratified with respect to firm size, region (East/West Germany) and sector affiliation. The survey achieves a response rate of about 25% each wave. The interviewed persons have the choice between responding via paper and pencil or online. The questionnaire consists of two parts. In the first part, companies complete questions on their current business development with respect to the previous quarter as well as their expectations for the next quarter. The second part is dedicated to questions concerning diffusion and use of ICT and further firm characteristics like innovative activities or training behavior. The questions in the second part change every quarter and might be repeated annually or biyearly. Details on the survey design are presented in Vanberg (2003). The survey is constructed as a panel. The questions on enterprise software usage were asked for the first time in the second quarter of 2007 and for the second time in the third quarter of 2009. Questions about innovative activities were asked in the second quarter of 2009. Thus, a panel data analysis cannot be provided in this paper. Therefore, we focus on a cross-section analysis, by merging the second wave of the year 2007 and the second wave of the year 2009. Considering item non-response for enterprise software and innovation, a sample of 335 firms remains.

The mentioned intangibility of services makes it difficult to measure innovation in the service sector or to distinguish between service, process or organizational innovation[9], as services are often regarded as processes[10]. Hipp and Grupp (2005) mention that this distinction is relevant as the impact of innovation in the creation of new markets and the impact on employment and productivity might be different for these types of innovation. According to the OSLO Manual (2005) we define service innovations in our analysis as a completely new service that has been introduced or at least essentially improved between June 2008 and June 2009. Service innovation is measured as a dummy variable

[8]For further details on the nine sectors, see the data description and Table 4 in the appendix.
[9]See OSLO Manual (2005) for a definition of all innovation types.
[10]Further details are provided by Tether (2005).

that takes the value one for firms realizing a service innovation and zero otherwise. This dummy variable represents the dependent variable in our empirical analysis. The descriptive statistics show that one third of the firms developed new or significantly improved services between June 2008 and June 2009[11].

Additionally, the firms were asked about three types of enterprise software: standard generic applications, sector specific software and customized software. The three variables representing the use of enterprise software are dummy variables which take the value one if a firm uses the respective type of enterprise software in June 2007 and zero otherwise. Standardized generic applications of enterprise software are called "standard software" in the questionnaire. This actually includes for instance also usual office packages. Office packages do not belong to the category of enterprise software as they can also be used by private households. Moreover almost every firm uses office packages beside its employed enterprise software systems. Thus, this dummy variable might be strongly biased upwards.

Table 1: Descriptive Statistics: Use of Enterprise Software

Variable	**Percentage of Firms**	**Number of Observations**
standard software	93.13	335
sector specific software	75.82	335
customized software	37.91	335
sector specific or customized software	86.57	335

Source: ZEW Quarterly business survey among service providers of the information society, own calculations.

Table 1 shows that about 93 percent of the service firms use this so-called standard software. This high value might reflect our expectation that the variable standard software includes basic solutions such as office packages. Therefore, this dummy variable is dropped in our analysis to reduce measurement error and avoid potential bias. Thus, we exclusively focus on sector specific software and customized software. Table 1 shows that more than three quarters of the service firms use sector specific software and 38 percent of the firms use customized software. About 86 percent of the firms use either sector specific software or customized software. Interference between all types of enterprise software is possible.

[11]See Table 5 in the Appendix.

Table 2: Descriptive Statistics: Enterprise Software and Innovation Activity

Variable	Share of Innovative Firms	Number of Observations
sector specific software	36.61	254
customized software	53.54	127
sector specific or customized software	38.97	290

Source: ZEW Quarterly business survey among service providers of the information society, own calculations.

Table 2 shows that the share of firms realizing a service innovation between June 2008 and June 2009 and use sector specific software is 36 percent. In contrast, more than half of the firms using customized enterprise software realized service innovations in the covered time period. This relatively high share offers first descriptive evidence for our hypothesis that the use of customized enterprise software seems to be more important for firms' innovation activity compared to the use of sector specific software.

4 Analytical Framework and Estimation Procedure

Introduced by Griliches (1979), this study will be based on a knowledge production function, following the basic assumption that the output of the innovation process represents a result of several inputs linked to research and ongoing knowledge accumulation, such as, e.g., R & D investment or human capital (Vinding 2006). Taking the different routes through which knowledge might influence the firms' innovation activities into account, Roper et al. (2008) augment this function with even more inputs like enterprise characteristics, firm resources and organizational capabilities. In addition, we include enterprise software in the knowledge production function, providing first insights into the relationship between business sector specific or completely customized enterprise software usage and the firm's innovation activity. This yields the following innovation relation:

$$SI_i = f(ES_i, L_i, C_i, R_i, FA_i, FS_{i,-1}, FP_{i,-1}, controls) \tag{1}$$

with S_i covering service innovation for firm i, ES_i enterprise software used by firm i, L_i

the labor input, C_i the competitive environment, R_i the R & D activity of the firm i and FA_i the age of the firm. Former service and process innovations ($FS_{i,-1}$ and $FP_{i,-1}$) as well as controls like sector classifications and region dummy are also included. The employed explanatory variables and their temporal sequence are explained in detail in the following. The endogenous variable we use as measure for innovation contains the information whether the firms are service innovators or not. As this dependent variable is a dummy and we assume a normally distributed errorterm, the widely established probit model as, e. g., introduced in Greene (2003) is used for inference.

The labor input L_i consists of firm size, qualification structure of employees, age structure of employees and IT-intensity. We control for firm size by the logarithm of the number of employees. Larger firms tend to have more lines of activity and therefore more areas in which they can innovate. This is valid for both the manufacturing and the service sector, see, e. g., Meyer (2010) or Leiponen (2005) for further information. Firm size is reported for the year 2008.

We also consider the qualification structure of the workforce by creating three control variables: the share of highly qualified (university or university of applied science degree), medium qualified (technical college or vocational qualification) and low qualified (other) employees measured in June 2009. The share of low qualified employees is taken as the reference category. Qualification measures the suitable know-how that is essential for starting and enhancing innovations. Without the suitable know-how, neither of them is successfully possible (Meyer 2010). Therefore, we assume that the higher the qualification of employees, the higher the suitable know-how.

For the age structure of the employees we control with three variables. The first one represents the share of employees younger than 30 years (reference category), the second one the share of employees between 30 and 55 years and the third one the share of employees over 55 years. The age structure of the employees might have an impact on the firms' innovative behavior. Börsch-Supan et al. (2006) point out that on the one hand, the process of aging leads to a cutback of fluid intelligence which is needed for new solutions and fast processing of information. On the other hand, older workers may resist to innovation when their human capital depreciates. Due to this fact they could be more innovative. Thus the effect of age structure of employees on innovative activity is an ambiguous issue. The age structure was measured in June 2009 in our survey.

We proxy the IT-intensity of the firms by the share of employees working with a computer in June 2007. Licht and Moch (1999) mention that IT can improve the quality of existing services, in particular customer service, timeliness and convenience. Moreover the productive use of IT is closely linked to complementary innovations (Hempell 2005).

The effect of firm age on innovation activity is still an ambiguously discussed subject. Koch and Strotmann (2005) mention that innovative output is higher in younger firms than in older ones. However, it is lowest in the middle-aged (18-20 years) firms and raises again with an age of over 25 years. On the one hand, firms could lose their adaptability to the environment with an increasing age or, on the other hand, organizational aging increases innovativeness due to learning processes. Firm age is also measured in the year 2008.

The competitive situation is another relevant issue for innovative activity. We created three dummy variables representing the number of main competitors in June 2009 according to the firms' self assessment. The first one includes zero to five competitors, the second one six to twenty competitors which is our reference category and the last one more than 20 competitors. The relationship between innovation and competition is supposed to look like an inverted U curve (Aghion 2005). A monopolist has less incentives to innovate as it already enjoys a high flow of profit. In a competitive situation, there are less incentives to innovate if there is no possibility to fully reap the returns of the innovation (Gilbert 2006).

One major difference between manufacuring firms and service firms is internal R & D activity. Internal R & D is a driving force for innovation in the manufacuring sector as it is the result of scientific research but it has to be treated differently in the service sector. Internal R & D activity in the service sector usually results in new knowledge or use of knowledge to devise new applications. It consists for instance of feasibility studies on research projects, development of new software applications or the development of new techniques for investigating consumer behavior for the purpose of creating new services. The development of new methods for measuring consumer expectations and preferences also belong to internal R & D[12]. Hipp and Grupp (2005) state that only few firms in the service sector are engaged in internal R & D activity or apply it on a continual basis. The exceptions form technology-oriented sectors as their amount of internal R & D activity is comparable to the amount of the firms in the manufacturing sector. As three of our

[12]A definition of R & D can be found in the Frascati Manual (2005).

industries in the sample belong to the information and communication service providers that are technology-oriented, we include a dummy variable that controls for internal R & D activity. It takes the value one if the firms carried out internal R & D during the last twelve months (June 2008 until June 2009) and zero otherwise. About one third of the firms in our analysis undertook internal R & D activities between June 2008 and June 2009[13]. Internal R & D activity takes place in the same time period we measure service innovations and thus leads to a potential endogeneity problem. Despite this potential problem, we keep this variable in our empirical analysis as internal R & D is rather regarded as an innovation input that leads to innovation than a result, see e.g. Hall et al. (2009).

There are several reasons for taking former innovation into account in our analysis. One of them is that innovative expercience plays an important role in explaining innovation. Innovation success in the past leads to a higher probability for innovation success in the future, a phenomenon called "success breeds successs" (Flaig and Stadler 1994, Peters 2007, Peters 2009). Another reason is due to a possible endogeneity problem, as it is not clear whether customized software leads to innovation or if innovative firms apply customized software as a diffusion channel for innovations. Both enterprise software variables were measured in June 2007 and our innovation variable between June 2008 and June 2009, so there is actually a time shift forming a well defined temporal sequence. Nevertheless, it is still possible that firms purchased their enterprise systems in June 2007 for the diffusion of new services starting in June 2008. The data does not offer an appropriate instrument to control for this potential endogeneity issue. We use two dummy variables for former innovation. The first one is former service innovation that takes the value one if the firm realized at least one new or essentially improved service between March 2006 and March 2007. The second dummy variable is former process innovation that takes the value one if the firm implemented new or essentially improved technologies during the same period of time. Both types of former innovations are important for our analysis as service and process innovations are dynamically interrelated.

In addition, we use nine sector dummies to control for industry-specific fixed effects. A dummy variable for East Germany accounts for potential regional differences.

[13]See Table 5 in the Appendix.

5 Results

Table 3 shows the average marginal effects of the probit estimation of equation (1)[14]. In the first model specification we estimate the raw effect of both enterprise software types on service innovation. The results indicate that sector specific software has no impact on service innovation. Firms using customized enterprise software instead are more likely to innovate than firms which do not use this type of enterprise software. The probability to innovate is about 24.2 percentage points higher for firms using customized enterprise software, a result based on high significance.

In the second specification we include firm size, firm age and IT-intensity. The impact of sector specific and customized software on service innovation remains qualitatively unchanged in this specification. Firms using customized software still have a probability to innovate that is 22.8 percentage points higher than firms not using this type of enterprise software. We observe that larger firms have a higher probability of innovating. The marginal effect is significant at the five percent level. Firm age and IT-intensity have no effect on service innovation. In case of the insignificant impact of IT-intensity in our analysis, we can conclude that the positive and significant impact of customized enterprise software measures not only the so-called "IT-effect" in general but the real effect of this type of enterprise software once we control for IT-intensity. Otherwise the positive impact of customized enterprise software would turn insignificant once IT-intensity is controlled for.

In the third specification, further variables measuring competitive situation, qualification structure and age structure of employees are added. Again, the impacts of both enterprise software systems do not change compared to former specifications. The probability of realizing service innovations is about 26.4 percentage points higher for firms using customized software in contrast to firms using sector specific software or no enterprise software at all. Older firms are less likely to innovate. The estimated marginal effect is significant at the five percent level. The age structure of the workforce reveals some interesting results. Firms with a higher share of employees between 30 and 55 years as well as employees over 55 years are less likely to innovate. The impact of employees between 30 and 55 years is significant at one percent while the impact of employees over 55 years is only significant at ten percent.

[14]Sample averages of the changes in the quantities of interest evaluated for each observation. Table 7 in the appendix contains the coefficient estimates.

Table 3: Probit Estimation Results: Average Marginal Effects

dependent variable: dummy for service innovation					
	(1)	(2)	(3)	(4)	(5)
sector specific software	-0.055	0.026	-0.011	-0.057	-0.052
	(0.060)	(0.064)	(0.073)	(0.071)	(0.080)
customized software	0.242^{***}	0.228^{***}	0.264^{***}	0.265^{***}	0.184^{**}
	(0.054)	(0.060)	(0.065)	(0.063)	(0.073)
log. firm size		0.047^{**}	0.026	0.024	0.028
		(0.020)	(0.023)	(0.021)	(0.024)
log. firm age		-0.065	-0.150^{**}	-0.163^{***}	-0.112
		(0.055)	(0.063)	(0.060)	(0.071)
IT-intensity		0.056	-0.065	-0.105	0.028
		(0.110)	(0.131)	(0.125)	(0.147)
competitors $0-5$			-0.028	-0.032	0.009
			(0.078)	(0.074)	(0.086)
competitors > 20			-0.055	-0.053	-0.031
			(0.071)	(0.068)	(0.073)
highly qualified employees			0.026	0.055	0.004
			(0.124)	(0.121)	(0.135)
medium qualified employees			0.018	-0.007	-0.161
			(0.165)	(0.162)	(0.177)
employees $30-55$ years			-0.468^{***}	-0.513^{***}	-0.288
			(0.172)	(0.165)	(0.187)
employees > 55 years			-0.368^{*}	-0.441^{**}	-0.298
			(0.221)	(0.210)	(0.235)
internal R & D-activities				0.259^{***}	0.219^{***}
				(0.071)	(0.084)
former service innovation					0.218^{***}
					(0.082)
former process innovation					-0.069
					(0.070)
dummies		Sector	Sector	Sector	Sector
		East	East	East	East
observations	335	298	240	233	172
pseudo R^2	0.046	0.103	0.147	0.217	0.259

Significance levels: *: 10%, **: 5%, ***: 1%. Reference categories: competitors 6-20, unqualified employees, employees <30 years.

The fourth model specification comprises additionally internal R & D activities. The results in the fourth specification show that firms untertaking internal R & D activities have a probability to innovate that is about 25.9 percentage points larger than the probability for firms which do not untertake internal R & D activities. This result is significant at the one percent level. However, we can only confirm a correlation between internal R & D and service innovation here instead of a causal effect due to the mentioned potential endogeneity problem. The impacts of the other control variables remain qualitatively unchanged in this specification. Again, firms using customized software have a probability to innovate that is 26.5 percentage points higher than firms not using this type of enterprise software or no enterprise software at all.

In the fifth specification, we include dummy variables measuring former service and process innovations to capture the "success breeds success" phenomenon. Based on a high significance level, the coefficient estimate points out that the probability to innovate is about 21.8 percentage points larger for firms which have already realized service innovations in the past. The average marginal effects of customized software and internal R & D activity remain both positive and significant suggesting that customized software as well as internal R & D activity lead to service innovation. The probability to innovate increases about 18.4 percentage points for firms using customized enterprise software in contrast to firms not using this type of enterprise software. Additionally the probability for enhancing service innovations increases about 21.9 percentage points if a service firm undertakes internal R & D activities. Therefore, internal R & D activity is at least also crucial for the service providers of the information society. This result gives a hint that the causality runs from customized software and internal R & D to service innovation once former service innovation is controlled for[15]. Otherwise the impact of both variables would turn insignificant. The inclusion of former service innovation weakens the impact of customized software by reducing its significance level from one to five percent. In contrast to former service innovation, former process innovation does not have any impact on current service innovation. The impact of firm age and and employees between 30 and 55 years and employees over 55 years turns insignificant by including former innovations into the model specification.

The comparison of our results to fromer studies reveals that Köhler et al. (2009) find a positive and highly significant impact of internal R & D expenditures on radical innovations in the service sector which supports our results. Furthermore, Peters (2009)

[15] A robustness check leaving out the internal R & D variable does not change the results qualitatively.

confirms our results, and thus the "success-breeds-success"-phenomenon, by finding a positive and significant impact of former innovations in the service sector on current innovations. There is no econometric evidence on the use of sector specific or customized software so far, thus we cannot compare these results directly to former studies.

In summary, we can conclude that firms using customized enterprise software have a higher probability of innovating compared to firms without this type of enterprise software or sector specific enterprise software[16]. This result is robust across all specifications and supports our hypothesis that customized enterprise software applications tailored to specific firms' needs optimize the internal processes which help to enhance service innovation as these processes are crucial for the provision of services. Due to the possible interrelation between sector specific und customized enterprise software we also estimated the model with an interaction term of the two enterprise software systems as a robustness check. The interaction effect is not significant in all specifications and does not change the other results qualitatively. Thus the use of both enterprise systems together offers no additional impact on innovation activity.

The consideration of former innovations reduces our sample to the very low size of 172 observations. Due to the insufficient panel structure, we decided to estimate all specifications with this reduced sample size as another robustness check, pictured in Table 6 in the appendix. As a further robustness check, we estimate all specifications without the industry and regional fixed effects. The results regarding the use of sector specific and customized enterprise software did not change qualitatively in all of our robustness checks[17]. As a last robustness check, the dummy variable for standard software was included in the empirical analysis leading to almost unchanged results as well.

6 Conclusion

This paper analyzes the relationship between different types of enterprise software systems and innovation in services. It attempts to identify if there is a difference between sector specific and customized enterprise software regarding innovation activity. Sector specific enterprise software is an off-the-shelf software designed and standardized for certain industries while customized software is designed and adopted to the needs of a

[16]See last column of Table 3.
[17]The average marginal effects without industry and regional fixed effects are available upon request.

single firm leading to unique features. In the service sector, enterprise software is an essential tool for providing services. Therefore, it might represent a crucial contribution to the innovation performance of a firm. The analysis is based on a knowledge production function constituted by an innovation equation with data of about 335 German firms in the ICT- and knowledge-intensive service sectors.

We find that ICT and knowledge-intensive service firms using customized enterprise software that fulfills their specific requirements are more likely to innovate compared to firms that do not use this type of enterprise software or use sector specific enterprise software. This means that the incorporation of long-term experience and knowledge in the software application contributes to a great amount to the innovation activity of service firms as it reflects all needed business processes leading to their optimization. It is important to mention here that customized enterprise software can only support service innovation if it is developed and applied properly, if the firm has complete knowledge of its organizational structure and processes and is aware of the goals it wants to achieve by using customized enterprise software. These facts ensure an enterprise software system that is perfectly suitable for all business requirements. Only given these circumstances, service firms are able to profit from the quickly delivery of information, enhanced knowledge processing, strengthening connections of information sources or reflection of all needed business processes customized enterprise software is linked to. Another benefit that arises for firms using customized enterprise software and especially developing it themselves, is the increased IT know-how. This know-how is an essential tool for innovation, especially ICT-intensive service providers could generate benefits out of it as software development, for instance, is one major task in these industries. In contrast, firms that use sector specific enterprise software cannot exploit these mentioned benefits. Although this type of enterprise software is very supportive by providing frequently updated databases or presenting information in an adequate manner, these advantages alone are, based on our results, not enough for supporting service innovation.

However, the topic of this paper needs further research as the causality cannot be completely solved econometrically here. An adequate instrument for enterprise software, a larger and more detailed data set or a panel data analysis might solve the causality problem. Due to data restrictions we pass this on to future research.

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7 Appendix

The ZEW quarterly business survey among service providers of the information society includes the following industries (NACE Rev.1.1 Codes of European Community in paranthesis): software and IT services (71.33.0, 72.10.0-72.60.2), ICI-specialized trade (51.43.1, 51.43.3-3.4, 51.84.0, 52.45.2, 52.49.5-9.6,), telecommunication services (64.30.1-0.4), tax consultancy and accounting (74.12.1-2.5), management consultancy (74.11.1-1.5, 74.13.1-3.2, 74.14.1-4.2), architecture (74.20.1-0.5) technical consultancy and planning (74.20.5-0.9), research and development (73.10.1-73.20.2) and advertising (74.40.1-0.2). Table 4 shows the distribution across industries in the sample of 335 observations.

Table 4: Distribution of Industries in the Sample

Industry	**Observations**	**Percentage**
software and IT services	43	12.84
ICT-specialised trade	33	9.85
telecommonication services	13	3.88
tax consultancy and accounting	56	16.72
management consultancy	37	11.04
architecture	54	16.12
technical consultancy and planning	33	9.85
research and development	38	11.34
advertising	28	8.36
sum	335	100

Source: ZEW Quarterly business survey among service providers of the information society, own calculations.

Table 5: Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
service innovation	0.385	0.487	0	1	335
sector specific software	0.758	0.428	0	1	335
customized software	0.379	0.485	0	1	335
number of employees	37.264	65.525	1	449	333
log (number of employees)	2.711	1.323	0	6.107	333
firm age	20.009	13.300	2	108	309
log (firm age)	2.850	0.519	0.693	4.682	309
0-5 competitors	0.244	0.430	0	1	311
6-20 competitors	0.305	0.461	0	1	311
more than 20 competitors	0.450	0.498	0	1	311
share of employees working with PC	0.787	0.266	0.01	1	323
share of highly qualified employees	0.436	0.319	0	1	315
share of medium qualified employees	0.159	0.195	0	1	302
share of low qualified employees	0.382	0.297	0	1	310
share of employees younger than 30 years	0.193	0.180	0	1	307
share of employees between 30 and 55 years	0.656	0.219	0	1	317
share of employees older than 55 years	0.160	0.176	0	1	306
internal R & D activities	0.302	0.459	0	1	321
former product innovation	0.414	0.493	0	1	258
former process innovation	0.437	0.497	0	1	265

Source: ZEW Quarterly business survey among service providers of the information society, own calculations.

Table 6: Probit Estimation Results: Average Marginal Effects, Reduced Sample

dependent variable: dummy for service innovation					
	(1)	(2)	(3)	(4)	(5)
sector specific software	−0.060	−0.028	−0.044	−0.051	−0.052
	(0.080)	(0.085)	(0.086)	(0.083)	(0.080)
customized software	0.308***	0.272***	0.257***	0.232***	0.184**
	(0.071)	(0.074)	(0.074)	(0.073)	(0.074)
log. firm size		0.039	0.034	0.032	0.028
		(0.024)	(0.025)	(0.024)	(0.024)
log. firm age		−0.170**	−0.161**	−0.169**	−0.111
		(0.070)	(0.072)	(0.070)	(0.073)
IT-intensity		0.100	0.055	0.050	0.027
		(0.137)	(0.156)	(0.150)	(0.148)
competitors $0-5$			0.038	0.029	0.009
			(0.094)	(0.091)	(0.087)
competitors > 20			−0.023	−0.017	−0.031
			(0.078)	(0.075)	(0.074)
highly qualified employees			0.052	0.014	0.004
			(0.143)	(0.140)	(0.136)
medium qualified employees			0.001	−0.129	−0.163
			(0.179)	(0.182)	(0.178)
employees $30-55$ years			−0.349*	−0.359*	−0.288
			(0.198)	(0.194)	(0.189)
employees > 55 years			−0.339	−0.376	−0.300
			(0.250)	(0.241)	(0.237)
internal R & D-activities				0.252***	0.220***
				(0.083)	(0.084)
former service innovation					0.219***
					(0.082)
former process innovation					−0.070
					(0.070)
dummies		Sector East	Sector East	Sector East	Sector East
observations	172	172	172	172	172
pseudo R^2	0.082	0.163	0.179	0.222	0.256

Significance levels: *: 10%, **: 5%, ***: 1%. Reference categories: competitors 6-20, unqualified employees, employees <30 years.

Table 7: Probit Estimation Results: Coefficient Estimates

dependent variable: dummy for service innovation					
	(1)	(2)	(3)	(4)	(5)
sector specific software	-0.151	0.078	-0.036	-0.193	-0.193
	(0.164)	(0.191)	(0.226)	(0.240)	(0.291)
customized software	0.633^{***}	0.630^{***}	0.767^{***}	0.839^{***}	0.634^{***}
	(0.144)	(0.166)	(0.194)	(0.204)	(0.246)
log. firm size		0.139^{**}	0.082	0.081	0.107
		(0.060)	(0.072)	(0.075)	(0.091)
log. firm age		-0.192	-0.463^{**}	-0.556^{***}	-0.420^{**}
		(0.164)	(0.201)	(0.214)	(0.273)
IT-intensity		0.166	-0.203	-0.357	0.107
		(0.325)	(0.405)	(0.428)	(0.549)
competitors $0-5$			-0.088	-0.112	0.036
			(0.245)	(0.259)	(0.319)
competitors > 20			-0.170	-0.181	-0.116
			(0.219)	(0.231)	(0.274)
highly qualified employees			0.082	0.190	0.016
			(0.383)	(0.412)	(0.504)
medium qualified employees			0.058	-0.026	-0.602
			(0.512)	(0.552)	(0.666)
employees $30-55$ years			-1.445^{***}	-1.745^{***}	-1.073
			(0.554)	(0.593)	(0.711)
employees > 55 years			-1.136	-1.501^{**}	-1.110
			(0.692)	(0.734)	(0.890)
internal R & D-activities				0.813^{***}	0.739^{***}
				(0.224)	(0.276)
former service innovation					0.740^{***}
					(0.271)
former process innovation					-0.267
					(0.279)
constant term	-0.426^{***}	-0.410	1.794	2.328^{**}	1.132
	(0.156)	(0.667)	(0.929)	(0.994)	(1.194)
observations	335	298	240	233	172
pseudo R^2	0.046	0.103	0.147	0.217	0.259

Significance levels: *: 10%, **: 5%, ***: 1%. Reference categories: competitors 6-20, unqualified employees, employees $<$30 years.