Empirical Analysis of Information Technology and Business Process Outsourcing

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Für Silke, Hannah und Romy

Abstract

This thesis consists of three essays that contribute to the empirical literature on information technology (IT) and business process outsourcing. The first essay analyses the impact of information technology outsourcing on labour productivity in outsourcing firms by using an endogenous switching regression model in a Cobb-Douglas production function framework. Estimation results show that employees who mainly work with a computer are more productive in firms conducting IT outsourcing. Therefore, computer usage and IT outsourcing can be interpreted as complementary factors that positively affect firms' labour productivity. The second essay refers to the employment effects of IT outsourcing. Even though, in most cases outsourcing is widely associated with accompanied job losses in outsourcing firms, the medium and long term effects of outsourcing can absolutely still be positive. The analysis is conducted by using an instrumental variable approach to account for possible endogeneity between the employment growth rate and IT outsourcing. Estimation results provide empirical evidence that IT outsourcing has a positive effect on a firms' medium-term employment growth rate. However, dividing the sample into manufacturing and service firms, a significant medium-term positive growth effect of IT outsourcing can only be observed for firms operating in the service sector. Finally, the last essay takes a close look at the impact of IT-related business process outsourcing on firm productivity. This analysis is based on panel data. In order to account for unobserved firm heterogeneity, measurement errors in the variables and simultaneity of inputs and output, different estimation techniques are applied to estimate a Cobb-Douglas production function model. The results clearly reveal a positive and significant impact of business process outsourcing on firm-level productivity.

Keywords:
information and communication technologies (ICT), outsourcing, business process outsourcing (BPO), productivity, employment growth, ZEW ICT survey

Zusammenfassung

Diese Dissertation befasst sich in drei empirischen Aufsätzen mit der Auslagerung von Informationstechnologien (IT) und Geschäftsprozessen. Der erste Beitrag untersucht die Auswirkung von IT-Outsourcing auf die Arbeitsproduktivität der auslagernden Unternehmen, wobei ein Endogenous Switching Regression Modell im Rahmen einer Cobb-Douglas Produktionsfunktion verwendet wird. Die Ergebnisse zeigen, dass Mitarbeiter, die hauptsächlich mit einem Computer arbeiten, produktiver sind in Unternehmen die IT auslagern. Daher kann die Computernutzung und IT Outsourcing als komplementäre Faktoren betrachtet werden, die sich beide positiv auf die Arbeitsproduktivität auswirken. Der zweite Aufsatz befasst sich mit der Wirkung von IT Outsourcing auf das Beschäftigungswachstum. Während Outsourcing zumindest kurzfristig oftmals mit einem Beschäftigungsabbau in den auslagernden Unternehmen assoziiert wird, können die mittel- bis langfristigen Auswirkungen von Outsourcing durchaus positiv sein. Durch einen Instrumentalvariablenansatz wird für mögliche Endogenität zwischen Beschäftigungswachstum und IT Outsourcing kontrolliert. Die empirischen Ergebnisse sprechen dafür, dass sich Outsourcing mittelfristig positiv auf das Beschäftigungswachstum der Unternehmen auswirkt. Allerdings zeigt eine separate Betrachtung des verarbeitenden Gewerbes und von Dienstleistungsunternehmen, dass dieser positive Effekt nur für letztere signifikant ist. Der dritte und letzte Beitrag untersucht die Auswirkung der Auslagerung von IT nahen Geschäftsprozessen auf die Unternehmensproduktivität. Diese Analyse basiert auf Paneldaten. Um Verzerrungen durch nicht beobachtbare Heterogenität von Firmen, Messfehler der Variablen und Simultanität der In- und Outputs zu erfassen, werden verschiedene Schätzverfahren im Rahmen einer Cobb-Douglas Produktionsfunktion verwendet. Die Ergebnisse zeigen einen signifikanten positiven Effekt der Auslagerung von Geschäftsprozessen auf die Produktivität der Unternehmen.

Schlagwörter:
Informations- und Kommunikationstechnologien (IKT), Auslagerung, Geschäftsprozessauslagerung, Produktivität, Beschäftigungswachstum, ZEW IKT-Umfrage

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Introduction

As a business manager, you need to take a hard look at your core competencies. Revisit the areas of your company that aren't directly involved in those competencies, and consider whether Web technologies can enable you to spin off those tasks. Let another company take over the management responsibilities for that work, and use modern communications technology to work closely with the people—now partners instead of employees—doing the work. In the Web work style, employees can push the freedom the Web provides to its limits.

Bill Gates, 1999 (*Time Magazine*, Vol. 153, No. 11)

During the last half century, there have been rapid technological developments in the fields of information and communication technologies (ICT) characterised by the availability of continuously increasing computing power of mainframe computers and the rapid spread of high-speed internet connections. Especially the advances in the fields of computer software and the tremendous progress made in online applications lately led to various new business models being developed by firms. But also 'traditional' businesses both in manufacturing and service industries benefited from these technological achievements by introducing ICT in their production and business service processes. The impressive productivity growth during the 1990s in the U.S. was widely associated with these investments in ICT (Jorgenson and Stiroh, 2000; Oliner and Sichel, 2000). Although some criticism of this view emerged stating that the productivity revival in the U.S occurred only in the ICT producing sector and not economy wide

(Gordon, 2000), researchers found by the availability of new data and the extension of the analysis to other countries robust and substantial economy wide productivity contributions of ICT (Brynjolfsson and Hitt, 2003; Hempell, 2005; Matteucchi et al., 2005). However, several studies also highlight that ICT is an 'enabling technology' whose productive usage requires complementary organisational changes as prerequisites for making ICT productive (Bresnahan and Trajtenberg, 1995; Brynjolfsson and Hitt, 2000; Bertschek and Kaiser, 2004; Arvanitis, 2005).

With the widespread use of ICT in firms and the increasing complexity of managing those technologies, a second trend manifested since the beginning of the 1990s: the outsourcing of information technologies (IT) and, subsequently, the outsourcing of ICT intensive business processes (BPO) to external service providers. The aim of this dissertation is to analyse whether the outsourcing of these services has any effects on the performance of the customer (outsourcing) firms, most notably in terms of productivity and employment. The analysis refers to the situation in Germany and therefore uses an extensive firm-level data set provided by the Centre for European Economic Research (ZEW) for the time period from 2000 until 2007.

To emphasise the importance of IT and business process outsourcing for Germany, first of all, the diffusion of ICT in German enterprises is presented briefly. The usage of ICT in the case of IT outsourcing basically reflects the need for accompanied services, which then might be provided in-house or from external service vendors. With BPO, the outsourcing of the entire (computer intensive) process is up for debate. Figure I.1 displays the shares of employees using a computer at work in selected German industries between 2003 and 2008. Although there are still substantial differences in the adoption of ICT between sectors, the regular use[1] of computers by employees is widespread in all sectors. In most industries, 40 and more percent of the employees used a computer in 2008. Computer use is especially prevailing in the sectors *research and development* (96 percent), *computer and related activities* (94), *other business activities* (86), *manufacture of paper products; publishing and printing* (77) and *wholesale trade and commission trade* (73). In some manufacturing industries, however, the shares are substantially lower, which mainly lies in the nature of the core tasks performed in those industries. Interestingly, during the last years, for some industries, substantial increases in the share of computer users at work are observable, as indicated by the right section of Figure I.1. In nine out of 23 industries, this increase is above ten percentage points between 2003 and 2008, where the most pronounced changes can be registered for the *other business activities* (33 percentage points), *manufacture of paper products; publishing*

[1] 'Regular use' in this context is defined as at least once per week.

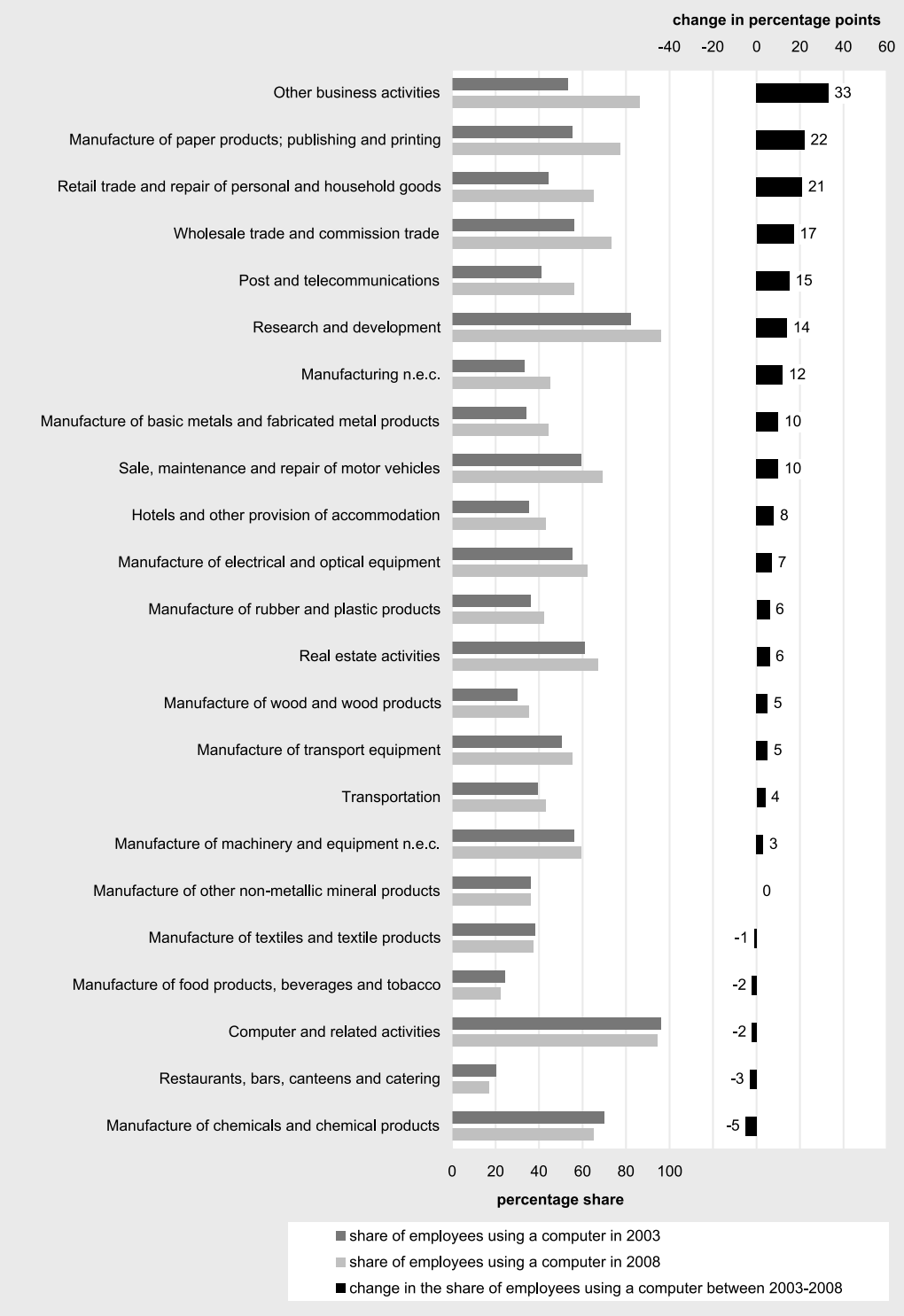
and printing (22) and *retail trade and repair of personal and household goods* (21) sectors.

Another measure for the ICT intensity of the firms is given by the share of employees using the internet for their daily work. Figure I.2 displays these shares referring to the same industries as above. The industries with the highest percentage shares of employees using the internet at work in 2008 are *computer and related activities* (96 percent), *other business activities* sector (92), *research and development* (79) and *manufacture of other non-metallic mineral products* (71). Sectors with the lowest internet usage by employees can again be observed in several manufacturing industries, as well as in the restaurant and catering sector. Interestingly, the employees in the *real estate activities* sector also use the internet to a lesser extent, although 67 percent of them regularly work with a computer. Looking at the change in the share of internet users in firms, the highest growth rates can be observed in manufacturing (besides the *research and development* and the *computer and related activities* sectors). The main reason for the more intensive use of the internet today than it used to be the case a couple of years ago might be the higher diffusion of appropriate broadband internet accesses. Probably more important, however, is the increasing availability of suitable internet based applications for managing business processes.

The use of sophisticated software and internet applications by German firms is quite high and has increased almost constantly over the last couple of years. Figure I.3 depicts these findings for a selection of software and internet related systems in the period 2002 to 2007. Procurement via the internet, the ordering of intermediate goods and materials from other firms, is most widespread and used by 78 percent of the firms in Germany. On the distribution side, using the internet for selling products, 52 percent are applying business-to-business (B2B) and/or business-to-consumer (B2C) e-commerce systems, thereby B2B is more widespread with a diffusion rate of 45 percent as opposed to 30 percent for B2C. Since the introduction of a corresponding web site for receiving orders is associated with substantial setup costs, the share of firms using the internet for e-commerce is far lower than the share of firms that use it for procurement. Additionally, for a lot of firms e-commerce ordering platforms are not the appropriate solution for selling their products.[2] Modern management methods based on electronic networks, such as enterprise resource planning (ERP), customer relationship management (CRM) and supply chain management (SCM) experienced a tremendous boost in use between 2002 and 2004. Since then, the share of firms applying those systems either stayed equal or increased slightly (in the case of SCM and ERP) or decreased by a few percentage points (in the

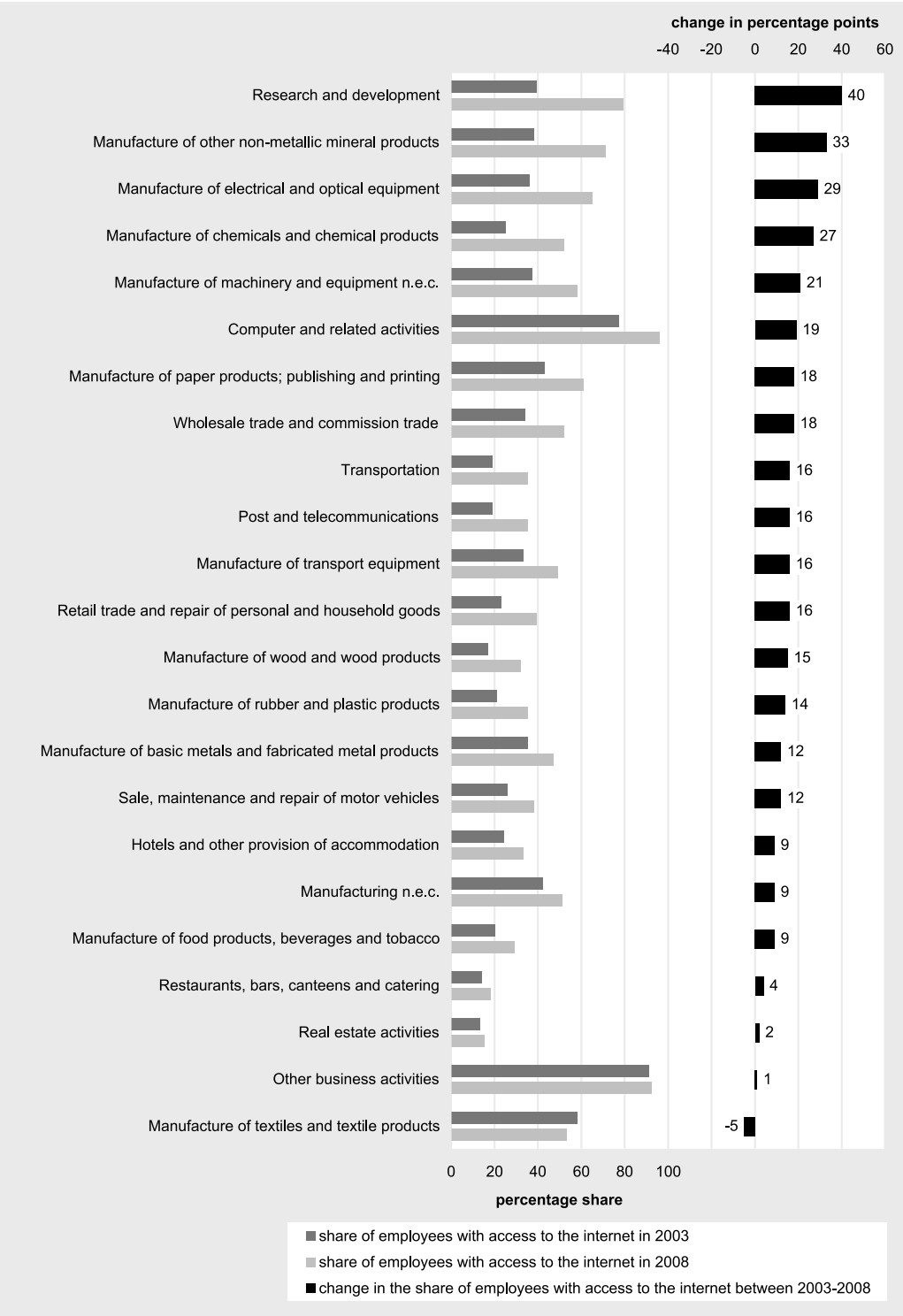
[2] For example, firms that produce specialised machinery, and each machine is unique and assembled to the specific needs of the costumer.

Figure I.1: Share of employees using regularly computer at work in selected industries



Source: ICT survey of the German Statistical Office 2003 and 2008 (Statistisches Bundesamt, 2004, 2008).

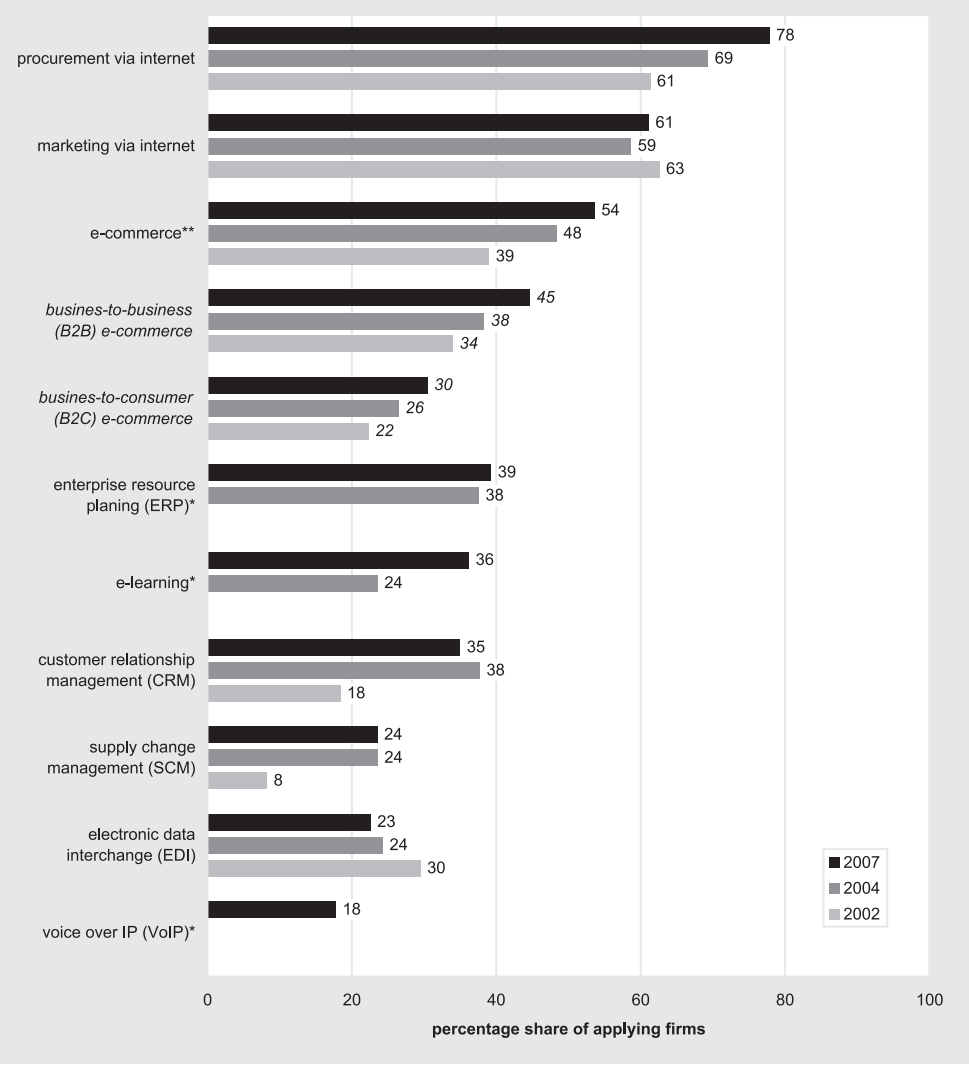
Figure I.2: Share of employees with access to the internet at work in selected industries



Source: ICT survey of the German Statistical Office 2003 and 2008 (Statistisches Bundesamt, 2004, 2008).

CRM case) between 2004 and 2007. The share of firms using electronic data interchange (EDI), however, is constantly falling. This is not surprising, since this standard of communication is more and more replaced by more modern internet communication and exchange. Additionally, almost all applications are used more intensively in manufacturing than in the service sector and their use is more pronounced in larger firms.

Figure I.3: Share of firms applying software and internet applications



Note: * Data for 2002 and/or 2004 not available. ** The application of B2B and/or B2C E-Commerce is subsumed under E-Commerce.
Source: ZEW ICT survey 2002, 2004 and 2007.

Summarising the results, although the use of computers and internet access by employees was already widespread at the beginning of the century, in most industries in Germany, the share of employees working regularly with a computer

and internet has further increased in recent years. Additionally, a proliferation in the general adoption of sophisticated software systems and internet related applications is observable. As a consequence, firms' demand for developing, implementing and administrating their ICT infrastructure increased, offering a potential market for IT and ICT intensive business process outsourcing.

According to Amiti and Wei (2005), the earliest use of the term 'outsourcing' in a service context appeared 1979 in the Journal of Royal Society of Arts. It was about the British auto industry contracting out engineering design work to Germany: *"We are so short of professional engineers in the motor industry that we are having to outsource design work to Germany."* However, until now, the term outsourcing is not uniquely defined in the literature. While some authors refer to outsourcing for any kind of external provision of intermediate inputs, others only include intermediates formerly provided by the company itself (in-house). Sometimes outsourcing even only refers to the external provision of (business) services and not to material inputs in any way. This view fits in the tradition of the first broad use of the outsourcing concept, which dates back to the big IT infrastructure outsourcing deals at the beginning of the 1990s.

Nowadays, the term outsourcing stands for all kinds of activities which lead to the relocation of production of goods and services. The relationship between the outsourcing and the vendor firm plays an important role in the outsourcing terminology. Both firms can be closely related if the vendor firm is legally a non independent spin-off of the client firm, which is basically offering its services exclusively to the parent company. The aim of this procedure is to create a unit with its own cost and profit responsibility without giving away full control.[3]

On the other hand, the vendor is really external and therefore negotiations of outsourcing contracts should not be influenced by firm specific relationships. Besides this legal issue of outsourcing, the location of the outsourcing provider gained much prominence in economic and political debate during the last decade. For outsourcing to a provider located abroad, the term offshoring is commonly established. Basically, abroad includes all foreign countries. But often in this discussion, low wage countries (with a substantial share of a high qualified and an English speaking workforce) like India, China or Eastern European countries are at the centre of focus. Offshoring to countries far away from the client firm is sometimes labelled farshoring and analogously nearshoring for close distance offshoring. Both legal specifications also apply to the case of offshoring, where production in a foreign country by an affiliated firm is also known as intra-firm or captive offshoring. Table I.1 depicts the various modes of producing services.

[3] Another reason for spinning-off an in-house department into an affiliate is to offer those services additionally to other firms. One prominent and successful example of this strategy in the case of IT outsourcing is Freudenberg IT in Germany.

Table I.1: Differentiation between outsourcing and offshoring

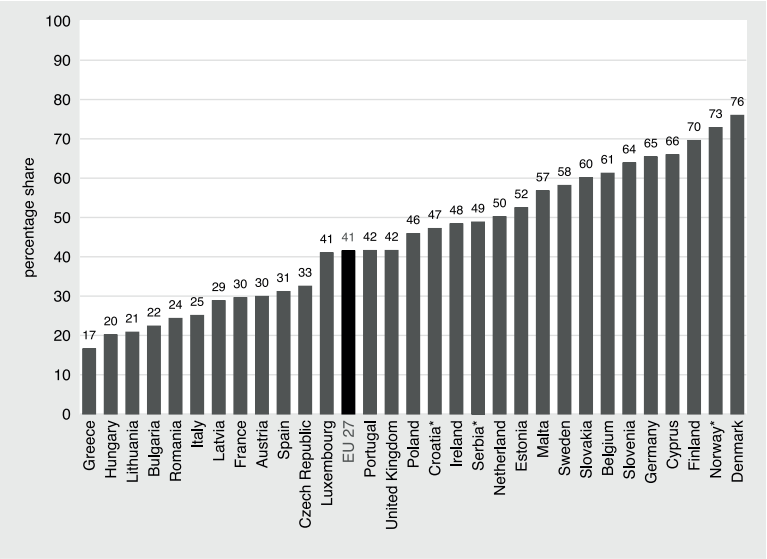
	internalised or externalised production	
location of production	internalised	externalised *("outsourcing")*
home country	production kept in-house at home	production outsourced to third-party service provider at home
foreign country *("offshoring")*	production by foreign affiliate "intra-firm (captive) offshoring"	production outsourced to third-party service provider abroad

Source: United Nations Conference on Trade and Development (2004, p. 148).

Looking specifically at IT outsourcing and BPO, both, like general outsourcing, still lack a consistent definition. IT outsourcing basically involves the contracting out of information technology services, like the installation of hard- and software, computer system maintenance, user assistance and support, etc., to an external service provider. One of the first and most cited definition of IT outsourcing is given by Loh and Venkatraman (1992a, p. 9). They define IT outsourcing as *"the significant contribution by external vendors in the physical and/or human resources associated with the entire or specific components of the IT infrastructure in the user organisation."* This means that any hardware as well as human capital (for example specialised IT employees) can be outsourced both partly or completely.

IT outsourcing experienced a boost after Eastman Kodak's landmark decision in July 1989 to hand over its entire data centre and microcomputer operations to an external consortium headed by IBM. This decision was widely seen as a major point of departure for the customary in-house mode of IT governance (Loh and Venkatraman, 1995). Due to the prominence of this case, IT outsourcing defused more rapidly as firms started to consider IT outsourcing as a viable strategic option (Loh and Venkatraman, 1992b). Information technology was not longer seen as absolutely strategic, and, therefore, not suitable for outsourcing. The mantra now was: *"If Kodak can do it, why can't every other organisation?"* (Dibbern et al., 2004, p. 8). In a fairly recent survey provided by Eurostat (2007), on average 44 percent of firms with at least 10 employees in the EU27 outsource (fully or partly) information and communication technology functions which require ICT/IT specialists in 2006. Some Scandinavian countries even reach values of more than 70 percent. Germany is also well above the average, with 65 percent of firms involved in IT outsourcing (see Figure I.4).

Figure I.4: Outsourcing of IT services in the European Union in 2006



Note: Enterprises with at least 10 employees where ICT functions requiring ICT/IT specialists were performed (fully or partly) by external suppliers during 2006. The financial sector is not included because of data comparability. *Included in the Eurostat statistic but not member of the EU 27.
Source: Eurostat 2006, ICT in enterprises statistics.

In the course of growing IT outsourcing shares and the increasing difficulties to separate technology and process aspects of computer related business processes, IT outsourcing vendors began to offer both services together. According to the International Data Corporation (IDC), one of the leading market research and analysis enterprises specialising in information technology, *BPO involves the transfer of management and execution of one or more complete business processes or entire business functions to an external service provider.* As opposed to pure IT outsourcing, BPO usually gives the vendor greater responsibility for the tasks performed, but, as a consequence, the vendor side also has to bear higher risks if processes fail to work. Typically, BPO comprises services from the area of finance and accounting, human resource management, procurement, logistic, customer care, programming and IT-infrastructure.

Estimates about the size of the IT and business process outsourcing market and its future prospects are numerous. The major problem with regard to those estimates is that most of them only rely on outsourcing contracts conducted by big enterprises, neglecting the amount of outsourcing contributed to the market by medium and small sized firms. According to an estimate of Gartner, a market research firm, the size of the global BPO market was assumed to rise to 172 billion US$ in 2009 starting from 111 billion US$ in 2004 (T-Systems, 2007). This amounts to a compound annual growth rate of more than 9 percent. The share of BPO outsourced to offshore contractors in 2009 was assumed to be

24.23 billion US$. NelsonHall, another market research firm, estimates the global BPO market value to reach 450 billion US$ by 2012. Compared to the Gartner figures, this would mean a tremendous increase in BPO during the next couple of years. For the global IT outsourcing market, Gartner estimated a 6.2 percent annualised increase from 193 billion US$ in 2004 to 260 billion US$ in 2008 (T-Systems, 2007).

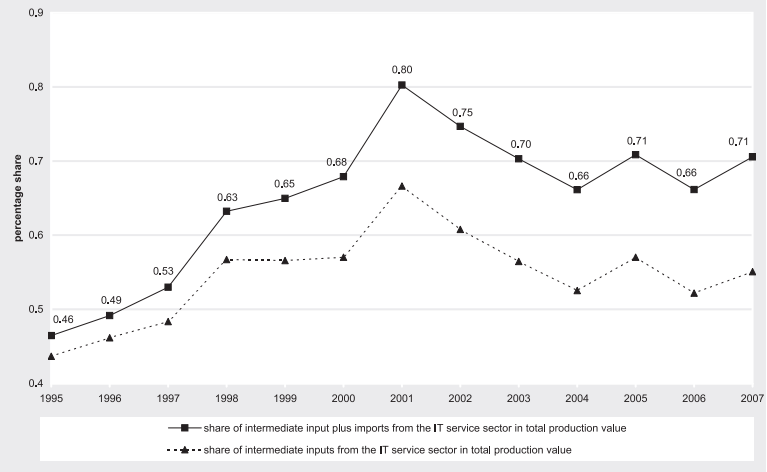
Another, more accurate way of measuring current and past IT and business process outsourcing market volumes is by means of input-output tables published by national statistical offices. Figure I.5 presents data from German input-output tables, which underlines the increasing use of external IT service providers during the last two decades. In 1995, 0.46 percent of the total production value was attributed to inputs from the IT service sector. This share rose to 0.71 percent in 2007, with a peak of 0.80 percent in 2001.[4] Although these percentage shares do not seem to be large, the absolute value of those IT inputs in 2007 amounts to almost 33 billion euro. Since those figures only reflect the outsourced part of the firms' IT services, the overall importance of IT as an input in the production process is substantially higher if, additionally, the provision of IT services within the firms is taken into account. The lower dashed line in Figure I.5 represents the share of intermediate IT services provided only by vendors located in Germany, consequently, the difference between the two lines reflects the IT offshoring activities (IT outsourcing to a provider located abroad) by German firms. As can be verified easily, the gap between the two lines rose between 1995 and 2007, which means that IT offshoring became more important. But still, the vast majority of intermediate IT services is provided by vendors located at home. With a total amount of almost 26 billion euro, German providers account for more than three-quarters of these services in 2007.

For BPO, it is more difficult to extract consistent information about the market size from available input output tables, since there is no distinct industry available for classifying BPO providers. However, Figure I.6 reflects the growing importance of external inputs from the *corporate service* sector[5] at the total production value in Germany between 1995 and 2007. The share of those intermediate inputs rose from 6.07 percent in 1995 to 7.5 percent in 2007

[4] Those numbers are based upon input-output tables provided by the German Statistical Office. IT services represent the sector "computer and related activities" which corresponds to NACE 72.

[5] The corporate service sector comprises firms belonging to the sectors *computer and related activities* (NACE 72), *research and development* (NACE 73) and *other business activities* (NACE 74). Of course, this is a very broad definition if one is focussing on business process outsourcing. Eurostat, for example, includes in the so called *business service sector* all firms belonging to NACE 72 and NACE 74.1 to 74.5. Because information from the input-output tables is only available on a two digit level, I decided to choose a wider definition.

Figure I.5: Share of intermediate IT input in total production value (Germany, 1995-2007)



Note: Services that were provided by the sector "Computer and related activities" which corresponds to NACE 72.
Source: Based on input-output tables provided by the Germany Statistical Office and authors' calculations.

which means a total increase of almost 23 percent. Although the increase in percentage point terms seems rather moderate (1.43), the demand for corporate services rose by (non-deflated) 153 billion euros between 1995 and 2007. Again, the share of imports is represented by the distance between the straight and the dashed line in Figure I.6. As can be easily verified, this share is only small but has been continuously rising during the last years.[6]

Economic theory offers several explanations for the outsourcing phenomenon. Starting with transaction cost theory, which dates back to Coase (1937) and its seminal work on the boundaries of the firm, a rich set of theories has been developed that deals with firm boundaries in vertical or input-output structures (Lafontaine and Slade, 2007). Vertical integration is the unified ownership and operation of successive production and distribution processes by a single firm. Backward integration, which is the focus of this work, occurs when a manufacturing or service firm controls the production or supply of inputs. Contrary, forward integration occurs when the firm controls the distribution of its products and services. The alternative to vertical integration is market exchange, that is to procure inputs and distribution services from independent suppliers. Vertical integration is also a matter of degree, as firms are often only partially integrated.

Coase was the first to explain that the boundaries of the firm depend not only on the productive technology, but also on the costs of transacting business. In a Coasian framework, the decision to organise transactions within the firm as

[6] In 2007, the share of imports from the corporate service sector amounted to 30 billion euros or 8.7 percent of the total inputs from this sector.

Figure I.6: Share of intermediate inputs from the "corporate service sector"* of the total production value (Germany, 1995-2006)

Note: *The "corporate service sector" comprises the sectors "computer and related activities" (NACE 72), "research and development" (NACE 73) and "other business activities" (NACE 74).
Source: Based on input-output tables provided by the Germany Statistical Office and authors' calculations.

opposed to the open market ("make-or-buy decision") depends on the relative costs of internal versus external exchange. This transaction cost theories have been developed further, most notably by Williamson (1971, 1975, 1979, 1985) and Klein et al. (1978). The open market mechanism entails certain costs: discovering the relevant prices, negotiating and enforcing contracts, and so on. Within the firm, the entrepreneur may be able to reduce these "transaction costs" by coordinating these activities himself. However, internal organisation causes other kinds of transaction costs, namely problems of information flow, incentives, monitoring, and performance evaluation. The boundary of the firm, then, is determined by the tradeoff, at the margin, between the relative transaction costs of external versus internal exchange. In this sense, firm boundaries depend not only on technology, but also on organisational considerations; that is, on the costs and benefits of various contracting alternatives. Especially important with regard to transaction cost theory is the degree to which relationship specific assets are involved, the amount of uncertainty about the future and the other parties' behaviour and the frequency with which the transaction occurs (Klein, 2005). The large body of empirical research in the area has found considerable support for the notion, derived from transaction cost theory, that specific investments are economically and statistically important when it comes to the decision to organise the production of a given input internally or externally. It has also been established that backward integration is more likely

for complex inputs and when the environment within which the firm operates is more uncertain (Lafontaine and Slade, 2007).

Another strand of the theoretical literature points into the direction of strategic management theory to explain why firms choose to outsource. Strategic management theory addresses firms' long-term goals and their plans to allocate resources to achieve these goals (Chandler, 1962; Miles and Snow, 1978; Porter, 1985; Quinn, 1980). When it comes to IT and business process outsourcing, one of the most cited arguments by firms (management) in favour of outsourcing is the wish to concentrate more on their own core competencies (see ZEW, 2005, for Germany; further references are given in Lacity et al., 2009). This is in line with the strategic management theory, which states that only core processes should be kept in-house, while contracting with other companies for ancillary activities and support services (Quinn and Hilmer, 1994). Indeed, many firms have recently abandoned their diversification strategies, which once were pursued to mediate risk and turned over to rely on market exchange in the provision of services. From a management point of view, there are two main reasons to rely on external vendors for non-core services: (a) external service provider possess economies of scale and technical expertise to offer those services more efficiently compared to in-house production, and (b) it allows managers to spend more time focusing on the firm's core competencies which in turn improves the return on the manager's efforts. Managerial incentives can then be restructured to emphasise the firm's core activities. Additionally, the managements loss of organisational competencies is low, since the outsourced activities are non-core (maybe neglected) services. However, the gains from outsourcing can be partially offset by increased coordination costs in outsourcing arrangements (Chalos and Sung, 1998).

To sum up, from a theoretical perspective, there are positive effects of IT and business service outsourcing expectable, since outsourcing firms competitiveness is strengthened by their increased concentration on their core competencies. Additionally, they benefit from the expertise of the external service provider in the fields of highly qualified human capital acquisition, which would otherwise be impossible to acquire, especially for small firms, and in the field of state of the art technology, for service provision. Finally, external vendors are able to provide services at lower prices because of scale effects.

The data underlying this dissertation stems from various waves of the ZEW ICT survey, a computer-assisted telephone survey conducted in German manufacturing and service firms. One of the reasons for introducing this survey was to fill the gap (especially in official statistics) of data availability concerning the use and diffusion of information- and communication technologies by firms. Since its first wave in 2000, four more waves followed until now (2002, 2004, 2007 and 2010). The ZEW ICT survey is a representative firm-level survey de-

signed by the research group Information and Communication Technologies at the Centre for European Economic Research (ZEW) in Mannheim, Germany.[7] In each survey year, around 4 400 successful firm interviews were conducted. Stratification was made by industry affiliation (14 sectors), firm size (eight size classes according to the number of employees) and region (West or East Germany).[8] The ZEW ICT survey particularly focuses on the diffusion and the use of information and communication technologies. Furthermore, there are a number of variables controlling for numerous firm characteristics. Since the ZEW ICT survey is constructed as an (unbalanced) panel, it is possible to combine different waves of the survey.[9]

In the following, a brief overview of the main results of this dissertation is given. While the first two chapters focus especially on information technology outsourcing and its effects on labour productivity and employment growth in the contract granting firms, the last part then extends the analysis by focusing on productivity effects of (computer intensive) business process outsourcing.

- **Labour Productivity and IT Outsourcing**
  Chapter 1 analyses the impact of IT outsourcing on labour productivity at the firm level. Cross sectional data from the ZEW ICT survey 2004 is therefore employed with a total of 2 534 observations. As analytical framework, an endogenous switching regression model within a production function framework is estimated in order to explore differences in labour productivity between IT outsourcing and non-IT outsourcing firms. By referring to this model, a possible selection bias in the decision whether to participate in IT outsourcing or not can be accounted for. For identification of this model, firms' participation in previous IT related consulting/outsourcing is used, namely the use of consulting services to deal with the year 2000 bug problem at the end of the last century.

  Besides labour and capital input, some other firm-level factors possible affecting labour productivity are included into the regressions. Most important here, the share of employees working at a computerised workplace. Estimation results show that employees working with a computer are more productive in IT outsourcing firms, while there is no significant difference between the capital and labour input coefficients in the two regimes. Computer workers and IT outsourcing can be interpreted as complementary factors positively affecting firms' labour productivity.

[7] The actual data collection was performed by an external market research institute.
[8] The underlying survey sample is drawn from the data base of the *Verband der Vereine Creditreform*, Germany's largest credit rating agency.
[9] The analysis in Chapter 3, for example, relies on four waves of the ZEW ICT survey.

Furthermore, IT outsourcing firms produce more efficiently than non-IT outsourcing firms.

- **Firm Growth and IT Outsourcing**
  Chapter 2 refers to the employment effects of IT outsourcing. Usually outsourcing is widely associated with accompanied job losses in the outsourcing firm, at least in the short run. However, the medium and long run effects of outsourcing on employment growth might still be positive. This analysis accounts for this by particularly focusing on IT outsourcing's medium-term effects on employment growth. Therefore, a three year time period from 2003 to 2006 is analysed using data from the ZEW ICT survey in 2004 and 2007. An instrumental variable approach is employed to account for possible endogeneity between the employment growth rate and IT outsourcing. As in Chapter 1, the use of consulting for the year 2000 bug problem and, additionally, previous standard wage rates are employed.

  The results provide empirical evidence that IT outsourcing has a positive effect on a firms' employment growth rate. However, dividing the sample into manufacturing and service firms, a significant medium-term positive growth effect of IT outsourcing can only be observed for firms operating in the service sector.

- **Productivity and Business Process Outsourcing**
  Finally, Chapter 3 takes a close look at the impact of business process outsourcing on firm productivity. The analysis is based on panel data including all waves of the ZEW ICT survey.[10] In order to take account of unobserved firm heterogeneity, measurement errors in the variables and simultaneity of inputs and output, different estimation techniques are applied, among them Olley and Pakes' (1996) approach and a system-GMM estimation technique (Arellano and Bover, 1995; Blundell and Bond, 1998), to estimate a Cobb-Douglas production function model. The results (over all estimation procedures) clearly show a positive and significant impact of business process outsourcing on firm-level productivity. According to the preferred system-GMM estimation results, the engagement in BPO has a positive effect of approximately 9 percent.

[10] This analysis uses for the first time the full panel structure of the ZEW ICT survey.

1 Productivity Effects of IT Outsourcing: An Empirical Assessment using Firm-Level Data

1.1 Introduction

Since the landmark Kodak IT outsourcing deal in 1989, when Kodak decided to source out substantial parts of their information technology (IT) to a consortium headed by IBM, IT outsourcing has increased considerably worldwide. According to Eurostat, on average 44 percent of European firms were engaged in IT outsourcing relationships in 2006, with some countries' shares as high as 70 percent and above (see Figure A1.1 in the appendix). While the public mainly perceives large outsourcing contracts of big companies, IT outsourcing is a widespread phenomenon especially in small and medium sized firms. In Germany, for example, 74 percent of the companies with five to 19 employees were engaged in IT outsourcing in 2009 (ZEW, 2010).

When IT outsourcing became more and more popular around the turn of the millennium, political and public debate was very controversial, reflecting the fear in industrialised countries of loosing high qualified jobs to transitional economies with high-quality and lower-cost labour pools. Thereby this debate largely ignored two important aspects of IT outsourcing. First, the majority of IT outsourcing is still assigned to vendors located within the home country of the outsourcing firm. Despite the technical advances and availability of high speed internet and communication channels, the proximity of client and vendor firms in IT outsourcing relationships is still an important issue (Arora and Forman,

2007).[1] This also implies that jobs are not going to be lost on a large scale, most of them are just transferred to other areas of the economy.

Secondly, possible positive firm level effects of outsourcing were ignored in this debate to a large extend. In this context, most often cost reductions, but also focus on a firm's core competencies are identified as enablers for a positive contribution of IT outsourcing to firm success. IT outsourcing firms might enjoy advantages since outside vendors can provide IT services at lower cost because of economies of scale. Additionally, management resources are released which until then were bound to overview and control in-house IT departments. These additional management capacities can be used to further develop a firm's core competencies which results in an increased firm value. However, IT outsourcing, as every other outsourcing relationship, is associated with transaction costs (Williamson, 1985), which include search and contracting cost, transition cost and managing costs (Aubert et al., 2004). These costs may cause productivity and competitiveness looses which may counteract the above-mentioned positive effects of outsourcing.

The growing importance of IT outsourcing was also accompanied by an increase in scientific research on this topic. Again, however, not much attention has so far been devoted to the performance effects of IT outsourcing for the contract granting firm using comprehensive data sets.[2] Notable exceptions are Bertschek and Müller (2006), Maliranta et al. (2008) and Han et al. (2010). Unfortunately, these studies come to different conclusions, which necessitates additional investigations. Opposed to IT outsourcing, research on the much broader topic of service outsourcing and its performance effects started earlier and is more complete. However, when it comes to IT outsourcing, relying only on the results achieved by those studies would be misleading because of the large heterogeneity within services. It is obvious that, for example, machine maintenance or janitorial services are hardly comparable with IT outsourcing services (Abraham and Taylor, 1996).

This chapter therefore contributes to the discussion about the consequences of outsourcing by specifically looking at IT services. The aim is to empirically identify the effect of IT outsourcing on firm level productivity. Therefore, an extensive German cross-sectional data set, comprising more than 2 500 firm observations, is available. Compared to previous work on the impact of IT

[1] For Germany, for example, a representative ZEW survey conducted in 2006 showed that only six percent of firms, mainly large firms in manufacturing, are involved in IT offshoring (ZEW, 2007). Although, the IT offshoring volume share is higher (as shown later in this chapter) the overwhelming majority of IT outsourcing is kept inside Germany.

[2] There are numerous case studies and analyses relying on (very) small samples on the performance effects of IT outsourcing, providing rather anecdotal evidence than reliable and representative results.

outsourcing on firm performance, based mainly on case studies and anecdotal evidence, this is a substantial increase in available observations and, furthermore, guarantees the drawing of a more representative picture of the overall effects of IT outsourcing for the entire economy. Methodologically an endogenous switching regression model (see Maddala, 1983, for further details) is employed, which divides outsourcing and non-outsourcing firms into two separate regimes. A selection equation controls for regime choice of the firms. This specification allows to take two different aspects into account: First, there might be a potential simultaneity between labour productivity and IT outsourcing. Causality can go in either direction, IT outsourcing might affect labour productivity or vice versa, since firms might outsource their IT tasks to increase productivity. Second, firms are allowed to produce according to different production function regimes depending on their decision to source out IT services to external providers. With this flexible framework, the presence of complementarities between IT outsourcing and the input factors can be accounted for.

The results show that while there are no significant differences in the output contributions of capital and labour inputs, employees working predominantly with a computer show a significantly higher contribution to labour productivity in firms engaged in IT outsourcing than in firms without IT outsourcing. This suggests that IT outsourcing firms exploit their "IT-capital" (in terms of computer users) more efficiently. Furthermore, multifactor productivity is significantly higher for IT outsourcing firms, thus reflecting a higher overall efficiency of these firms compared to their non-IT outsourcing counterparts. Overall, there is indeed a positive contribution of IT outsourcing regarding firm performance, and therefore, managers and policymakers should foster further IT outsourcing efforts of firms.

The chapter is structured as follows: Section 1.2 provides the background discussion and gives an overview of the literature on (IT) outsourcing and productivity. In Section 1.3, the estimation procedure is introduced. The data set and some descriptives are presented in the following Section 1.4. Section 1.5 discusses the estimation results, and Section 1.6 concludes.

1.2 Background Discussion

IT outsourcing can be described as the practice of turning over all or at least parts of an organisation's information technology functions to external service provider(s) (Grover et al., 1994). Typical IT function hereby are development and maintenance of applications, planing and management of systems, management of networks (and telecommunications, end-user computing support, and purchase of application software. As with all other outsourcing relationships,

IT outsourcing relationships can be further differentiated by regional and legal dimensions. While the regional aspect refers to the location of the outsourcing provider (either in the home country or abroad), the legal aspect considers if an outsourcing vendor is subsidiary of the contract granting firm or a truly independent external service provider. In this chapter, I do not specifically differentiate between foreign and local sourcing,[3], however, I make a distinction in the legal aspect by only considering arm's length IT outsourcing contracts. Besides data restrictions on this point, the assumption makes sense, since contractual outsourcing arrangements between a mother company and its (IT services providing) subsidiary might be driven by different factors compared to external IT outsourcing (Barthélemy and Geyer, 2005).

Estimations of the IT outsourcing market volume are varying, since the assumptions underlying those calculations are usually different. Gartner, for example, estimates that the global IT service market is expected to grow from 674 billion US$ in 2006 to 964 billion US$ in 2011. In many cases, estimates like this only capture huge IT outsourcing deals of big companies and disregard the significant amount of IT outsourcing made by small and medium sized firms. To present a broader and more accurate estimate of the German IT outsourcing market, I relied on input-output tables provided by the German Statistical Office. With this data, I calculated the share of inputs provided by the IT service sector[4] in the overall production value for the years 1995 to 2007.[5]. A graphical representation is given in Figure A1.2 (in the appendix). In 1995, 0.46 percent of the total production value was accounted to inputs from the IT service sector. This share rose to 0.71 percent until 2007, with a peak of 0.80 percent in 2001. Although, at a first glance, these percentage shares do not seem to be very large, the absolute euro values behind them are quite substantial. For 2007, for example, the total amount of external IT inputs amounts to 26 billion euros.[6] Since these figures only reflect the actually outsourced part of firms' IT services, the overall importance and the future potential of IT outsourcing is significantly larger. The lower dashed line in Figure A1.2 represents the share of intermediate IT services provided only by vendors located in Germany. Consequently, the difference between the straight and the dashed lines reflects the IT offshoring activities of the German economy. As can be easily seen, the gap

[3] IT outsourcing to a vendor located abroad is better known as IT offshoring. For Germany, IT offshoring seems not to be so important, since, as already mentioned, only a small proportion of firms are actually involved in IT offshoring relationships (ZEW, 2007).

[4] The IT service sector refers to NACE 72 – "Computer and related activities" in the NACE Rev. 1.1 definition.

[5] Currently, 2007 is the last year for which input-output data for Germany is available

[6] This estimate is in the range of the 31 billion euro market value in 2007 for IT services presented by *BITKOM*, the Federal Association for Information Technology, Telecommunications and New Media in Germany.

between the two lines rose in the observed time span, which means that IT offshoring became more important. Still, however, the vast majority of intermediate IT services is provided by vendors located at home. With a total amount of 18.4 billion euros, German IT providers account for almost three-quarters of externally provided IT services in 2007.

IT outsourcing research has long mainly focused on the determinants of IT outsourcing decisions. Early contributions have been made by Loh and Venkatraman (1992a), Grover et al. (1994), Lacity et al. (1996), Lacity and Willcocks (1998) and Smith et al. (1998), relying mainly on U.S. outsourcing practices of large scale IT outsourcing contracts. More recently, Henkel et al. (2003) and Barthélemy and Geyer (2004) examined German and French IT outsourcing contracts. Comprehensive overviews of this literature is presented by Dibbern et al. (2004) and Lacity et al. (2009).

With time progressing, researchers also started to take a closer look at the economic consequences of IT outsourcing, particularly its impact on productivity and profitability, for the contract granting firm. Basically, three channels were identified in the literature through which IT outsourcing can have a positive effect on firm's operational performance: cost reduction, focus on core competencies and flexibility. IT outsourcing can provide value to the outsourcing firm because of cost advantages. It is widely accepted that IT service provider achieve economies of scale, have tighter control over fringe benefits, better access to lower-cost labour and more focused expertise in managing information technologies. External vendors are therefore able to provide the same services at lower cost compared to an in-house IT department (Smith et al., 1998; Lacity and Willcocks, 1998). In a competitive provider market environment, these cost advantages are (at least partly) forwarded to the client firm.

When deciding to outsource IT functions, strategic aspects in the form of focusing on core competencies might play a crucial role. In most cases, firms' information technology functions are viewed as non-core activities. To manage these technologies effectively, senior management commitment and expertise is essential. When outsourcing IT, managerial effort can be preserved, which in turn can be devoted to business areas with greater strategic potential (Smith et al., 1998). Even selective outsourcing allows firms to source out significant portions of their internal IT services, while strategically important IT functions of the firm are retained in-house.

A firms value can also be enhanced through IT outsourcing when it allows greater flexibility for the contract granting firm (Grover et al., 1996; Poppo and Zenger, 1998; Quinn et al., 1990). Due to rapid technological advances in information and communication technologies, firms face the threat of their technical expertise and equipment becoming obsolete (Smith et al., 1998; Hayes et al., 2000). For IT outsourcing vendors, however, in order to be successful

in the market, it is important to employ state-of-the-art technologies, high quality IT personal and always introducing innovative practices. These assets help them, compared to in-house IT departments, to provide client firms with high quality IT services (DiRomualdo and Gurbaxani, 1998; Wang et al., 2008). Therefore, outsourcing firms are able to use new technologies and practices faster, without making large capital or human resource investments. Flexibility is additionally increased if firms are able to continuously tailor their IT outsourcing contracts to their constantly changing needs (Hayes et al., 2000).

Although the possible advantages of IT outsourcing can be numerous, there are also cost associated with outsourcing which in the worst case exceed all the possible benefits. Transaction costs (Williamson, 1985) associated with outsourcing are search and information costs, contracting costs, transition cost as well as the costs of maintaining the contract (Aubert et al., 2004).

So far, the empirical research on IT outsourcing and its impact on firm performance, as already mentioned, is quite scarce. Most contributions are based on anecdotal evidence or case studies (Grover et al., 1996; Lacity and Willcocks, 1998; Lee and Kim, 1999). However, there are some exceptions. Using a broad firm-level data base for the UK, Clayton (2005) finds that IT outsourcing is not a significant determinant of productivity when controlling for IT investments in hardware and software. The analysis conducted by Bertschek and Müller (2006) points in the same direction. They find that IT outsourcing does not significantly change the partial output elasticities of the production factors when using German data for the year 2000. Maliranta et al., however, using Finish data, identify a significantly higher productivity contribution of computer users which are supported by external service providers. In an extensive industry analysis for more than 60 U.S. industries comprising the years 1998 to 2006, Han et al. (2010) find that IT outsourcing has made a significantly positive contribution to output and labour productivity. Additionally, they state that higher IT intensive industries use more IT outsourcing as a percentage of their output but less as a percentage of their own IT capital, and they achieve higher returns from IT outsourcing. This leads them to their conclusion (and is opposed to the finding of Clayton (2005)) that firms need to develop IT capabilities by investing in IT themselves to gain greater value from IT outsourcing. Similar results are obtained by Wang et al. (2008).

More frequently, and due to data availability, the much broader field of service outsourcing has been subject of investigations in the literature. In general, service outsourcing can comprise all kinds of services, where the outsourcing of information technology can be considered as a special case. Therefore, the results achieved in this line of research are informative regarding IT outsourcing but have to be considered with caution.

When focusing on the productivity impacts of outsourcing by using industry-level data, Ten Raa and Wolff (2001) find a positive correlation between the rate of service outsourcing and productivity growth. Significant productivity impacts of service outsourcing are also observed by Amiti and Wei (2009). They find that foreign service outsourcing contributes to labour productivity increases in U.S. manufacturing industries. In contrast, they cannot detect a positive relationship between material offshoring and productivity. Especially earlier contributions based on industry data also constitute negative effects of service outsourcing. For example, Siegel and Griliches (1992) did not find correlation between post 1979 improvement in manufacturing productivity growth and an increase in service outsourcing. Fixler and Siegel (1999) report that outsourcing actually led to a short run reduction in service sector productivity.

Several empirical contributions to the literature using firm-level data are also available. Görzig and Stephan (2002) use several measures of outsourcing, among them a measure for externally provided services, when investigating the impact of outsourcing on German manufacturing firms' profitability. In the short run, they find a negative effect of service outsourcing, however, in the long run, this effect is positive and significant. Görg and Hanley (2004) consider the Irish electronics industry when looking at the impact of outsourcing on profitability. Although they can differentiate between domestic and international outsourcing, they only consider the latter one. Their results show that outsourcing enhances large firms profitability only and that a positive impact of (international) outsourcing can only be found for the outsourcing of materials. Also based on firm-level data, Girma and Görg (2004) are among the first who analyse the impact of outsourcing on productivity. Among others, they focus in their analysis on "nonindustrial services", which include accounting, consulting, cleaning, transportation, etc. Their analysis is based on UK plant-level data for three manufacturing industries: chemicals, engineering and electronics, and the results show that productivity is significantly positively affected by outsourcing in the chemical and engineering industry, but not in the electronic industry. Görg et al. (2008) concentrate on international outsourcing and differentiate between material and service outsourcing in Irish manufacturing industries. They find a positive effect of service outsourcing only for firms already active on the export market. In contrast, the impact of material offshoring is even negative for non-exporting firms. The link between international and domestic services outsourcing, profitability and innovation is analysed by Görg and Hanley (2010), drawing again on Irish plant-level data from manufacturing. They find that international outsourcing has a positive effect on profitability, although this does not appear to be the case for domestic outsourcing.

The results so far presented for IT outsourcing and service outsourcing are quite different, when it comes to their impact on firm (respectively industry)

performance. Certainly, one reason for this is that different countries, industries and time-spans are under consideration. Additionally, some studies focus on international outsourcing, some on domestic outsourcing only and some on both without differentiation. The most crucial point, however, might be the varying definition of IT and service outsourcing. The analysis in this chapter tries to account for this fact by choosing a precise IT outsourcing definition which comprises basic IT functions a firm can contract to external service providers.

1.3 Methodology

In order to investigate the impact of IT outsourcing on firms' labour productivity, an *endogenous switching regression model* within a production function framework is applied.[7] The endogenous switching regression model assumes that some unobserved factors affect the IT outsourcing decision and labour productivity simultaneously. In contrast to methods based on instrument variables, the endogenous switching regression allows IT outsourcing to change the entire set of partial productivity elasticities instead of limiting IT outsourcing to act only as a shift parameter in the productivity equation (Bertschek and Kaiser, 2004, p. 395).

The empirical specification assumes that firm i produces according to a Cobb-Douglas production technology. Output Y_i is a function of conventional capital K_i and an efficient measure of labour L_i^*, which itself depends upon the share of employees working predominantly at an computerised workplace in the firm. The production function can be presented as follows:

$$Y_i = f(A_i,\ K_i,\ L_i^*) \quad = \quad A_i\ K_i^{\alpha}\ L_i^{*\beta}. \tag{1.1}$$

Since I expect that employees may have different marginal products depending on whether or not they use a computer at work, I use a measure proposed by Greenan and Mairesse (2000) for the formulation of efficient labour, which can be stated as follows:

$$\begin{aligned} L_i^* &= L_i^{nc} + (1+\gamma_i)L_i^c \\ &= (L_i^{nc} + L_i^c)\left(1 + \frac{\gamma_i L_i^c}{L_i^{nc} + L_i^c}\right) \\ &= L_i(1+\gamma_i p_i), \end{aligned} \tag{1.2}$$

[7] For previous applications of the endogenous switching regression model in different contexts see, for example, Lee (1978), Bertschek and Kaiser (2004) and Bertschek et al. (2006). For a detailed and thoroughly discussion of the model, see Maddala (1983).

L_i^c is the number of employees predominantly working with a computer and correspondingly, L_i^{nc} is the number of those who do not work with a computer. $L_i(= L_i^{nc} + L_i^c)$ refers to the total number of employees in firm i (in fulltime equivalences). The share of computer users is represented by the parameter $p_i(= L_i^c/L_i)$. Relative labour efficiency between the employees working with a computer and those who work without a computer is then measured by γ_i.

The term A_i in equation (1.1) represents differences in production efficiency that are not related to the input factors and reflects multifactor productivity. The exponents α and β denote the output elasticities with respect to capital and efficient labour. Empirically, there are additional factors influencing firms' productivity. Therefore, a vector $\boldsymbol{X_i}$ with further explanatory variables is added to the model.[8] Inserting equation (1.2) into (1.1), dividing by L_i, taking logs on both sides and adding an i.i.d. error term denoted by u_i, labour productivity in log output per employee $\ln(Y_i/L_i)$ results in:[9]

$$\ln\left(\frac{Y_i}{L_i}\right) = \ln(A_i) + \alpha \ln(K_i) + (\beta - 1) \ln(L_i) + \beta\gamma p_i + \boldsymbol{X_i\theta} + u_i. \quad (1.3)$$

In a switching regression context, there is a separate production function specified for each of the two groups under consideration:

$$\begin{aligned} \ln\left(\frac{Y_i}{L_i}\right)_o &= \ln(A_{i,o}) + \alpha_o \ln(K_i) + (\beta_o - 1) \ln(L_i) \\ &\quad + \beta_o\gamma_o p_i + \boldsymbol{X_i\theta_o} + u_{i,o} \\ &= \boldsymbol{V_i\delta_o} + u_{i,o}, \end{aligned} \quad (1.4)$$

$$\begin{aligned} \ln\left(\frac{Y_i}{L_i}\right)_n &= \ln(A_{i,n}) + \alpha_n \ln(K_i) + (\beta_n - 1) \ln(L_i) \\ &\quad + \beta_n\gamma_n p_i + \boldsymbol{X_i\theta_n} + u_{i,n} \\ &= \boldsymbol{V_i\delta_n} + u_{i,n}. \end{aligned} \quad (1.5)$$

If firm i outsources IT functions to an external provider, its labour productivity is given by equation (1.4). If no outsourcing takes place, labour productivity is given by equation (1.5). The subscripts *o* and *n* denote the two productivity regimes *"outsourcing of IT services"* and *"no outsourcing of IT services"*.

[8] In detail, these are variables reflecting the qualification structure of the workforce, the existence of a works council, export share, whether a firm operates a foreign subsidiary, firm age, the implementation of software and internet systems, as well as a control variable for the location of the firm (East or West Germany) and industry dummies.

[9] The approximation $\ln(1 + \gamma p_i) \approx \gamma p_i$ is applied.

The endogenous switching regression approach takes into account that firms with and without IT outsourcing differ in terms of observable and unobservable characteristics. If unobservable factors, which influence the decision to outsource IT services, also have an impact on the firms' productivity, the expected values of the error terms in equations (1.4) and (1.5) are different from zero ($E[u_{i,o}] \neq 0$ and $E[u_{i,n}] \neq 0$). Simple OLS estimations would lead to inconsistent results. The selectivity bias can be corrected by first estimating the decision to outsource IT services using external identifying variables and, in a second step, adjusting the production function by adding a correction term accounting for the probability that a certain company engages in IT outsourcing.

Therefore, it is necessary to analyse which firms are involved in outsourcing activities. It is assumed that the IT outsourcing decision of the firm is positive if the expected gains from outsourcing are larger than the associated costs. Thus, firm i charges an external vendor with taking care of its IT services if the costs per employee associated with outsourcing C_i are smaller than the expected productivity increases resulting from outsourcing. The latent variable

$$I_i^* = a \left[\ln\left(\frac{Y_i}{L_i}\right)_o - \ln\left(\frac{Y_i}{L_i}\right)_n \right] - C_i + \epsilon_i = \boldsymbol{Z_i \pi} + \epsilon_i \qquad (1.6)$$

represents the difference between the productivity gains (weighted by the term a, which denotes the effect of the productivity gains from IT outsourcing on the decision to outsource) and the costs arising from IT outsourcing. The outsourcing decision is unaffected by the productivity differences if $a = 0$. However, I_i^* is not observable. What we can observe is I_i, which represents the behaviour of the firm regarding IT outsourcing. The selection mechanism is as follows:

$$I_i = \begin{cases} 1 & \text{if } I_i^* > 0 \\ 0 & \text{if } I_i^* \leq 0. \end{cases} \qquad (1.7)$$

The conditional expectations given in equation (A1.2) and (A1.3) (in the appendix) can be added as additional explanatory variables to equations (1.4) and (1.5), which results in

$$\ln\left(\frac{Y_i}{L_i}\right)_o = \boldsymbol{V_i \delta_o} + \sigma_{o,\epsilon}\, \lambda_{i,o} + \eta_{i,o}, \qquad (1.8)$$

$$\ln\left(\frac{Y_i}{L_i}\right)_n = \boldsymbol{V_i \delta_n} - \sigma_{n,\epsilon}\, \lambda_{i,n} + \eta_{i,n}, \qquad (1.9)$$

where $\eta_{i,o}$ and $\eta_{i,n}$ are the new residuals, with zero conditional means.

Additionally, one instrument variable that explains the IT outsourcing decision, but has no impact on labour productivity, is included for reasons of identification. This has to be a variable which is correlated with the IT outsourcing decision but is not affecting labour productivity. The instrumental variable chosen for this purpose is *Y2K consulting*. This is a binary indicator, which states whether a firm resorted on external consultancy for the year 2000 problem in the late ninetieth of the previous century.

The year 2000 problem (also known as the Y2K problem, the millennium bug, or the Y2K bug) is the result of a practice in early computer program design that caused some date-related processes to operate incorrectly in terms of dates and times on January 1, 2000 and afterwards. There was the threat that computer systems which were not adequately prepared for the time shift from 1999 to 2000 would break down completely. Since, already at that time, computer (systems) were widely used in companies, virtually all firms were equally exposed to the threat of the year 2000 problem. Media coverage and numerous information campaigns from chambers of commerce and industry and other associations flanked the time before 2000. A lot of new IT consultancies entered the market to provide expertise to firms regarding the year 2000 problem.[10] Once it had passed, those firms making use of external consultancies might be more inclined to start other information technology related outsourcing projects. With the experience of previous usage of external consultancy for IT problems, the choice of an adequate IT outsourcing vendor and especially the contract arrangement is much easier. This result is empirically underlined in the data by the significant correlation between IT outsourcing and Y2K consulting of 0.1741 (see Table A1.1 in the appendix). Since the Y2K outsourcing decision was made a long time before labour productivity for this analysis was observed, the impact of the Y2K decision is assumed to be fully internalised by then.

Besides the identifying variable Y2K consulting, various other firm characteristics are assumed to have an influence on the IT outsourcing decision. A negative effect is expected for the existence of a works council. It can be presumed that employee representatives are always opposed to outsourcing—and the associated lay-off of employees—of processes formerly conducted in-house. Additionally, if firms source out substantial parts of their production, a works council itself would loose influence within the firm. Furthermore, long negotiations between the management and the works council, to achieve an agreement about outsourcing, will also increase the total costs of outsourcing. Exporting firms are more exposed to international competition and, therefore, are used to adjusting more quickly to changes in the market environment. This higher flexibility is assumed to result in lower adjustment costs for IT outsourcing which

[10] Some even see a direct relationship between the Y2K problem and the rise of Indian IT providers, such as Wipro, Tata Consultancy Services and Infosys (Economist, 2003).

entails a positive effect on the IT outsourcing decision. A similar argument holds for firms which operate a foreign subsidiary. Again, these firms are confronted more with international competition, resulting in lower adjustment costs for the implementation of IT outsourcing. Furthermore, multinational firms are usually presumed to employ better technologies than domestic firms (Markusen, 1995), which makes IT outsourcing even more favourable. On the other hand, firms with a foreign subsidiary may be forced to use IT services provided by an within-group IT department, which would result in a negative effect.[11] The expected sign at the end depends upon the prevailing argument. For older firms, the cost of implementing IT and reorganising the production process is probably more expensive than for younger firms. According to Christensen and Rosenbloom (1995), younger firms are more flexible. Thus, they are more likely to adopt a new technology. Following this argument, younger firms might be more inclined to adopt a new business model (which in this case would be IT outsourcing). The number of software and internet related applications employed by the firm is supposed to have a negative effect on outsourcing. It is reasonable to assume that firms which use more IT applications have a more complex IT infrastructure, which can be better controlled by internal IT specialists. Furthermore, in firms with many IT applications, the IT infrastructure can be seen as part of the firms core competencies. They rely heavily on a perfect functioning of their applications in the production process. A decision to outsource core competencies is rather unlikely.

There are two different possible methods to estimate the endogenous switching regression model. A two-stage approach (see e.g. Lee, 1978), where a probit model of the selection equation is estimated in the first stage and the inverse Mill's ratios $\lambda_{i,o}$ and $\lambda_{i,n}$ are calculated according to equations (A1.2) and (A1.3). In the second stage, equations (1.8) and (1.9) are estimated. However, the residuals $\eta_{i,o}$ and $\eta_{i,n}$ are heteroscedastic (Maddala, 1983, p. 225). Since the variables $\lambda_{i,o}$ and $\lambda_{i,n}$ have been estimated, the residuals $\eta_{i,o}$ and $\eta_{i,n}$ cannot be used to calculate the standard errors of the two-stage estimates. Studies applying endogenous switching regression models so far have used the method presented by Maddala (1983, pp. 225-226) for estimating the correct variance-covariance matrix. The endogenous switching model can be estimated more efficiently by applying the *full information maximum likelihood* (FIML) method, where the selection equation and the regime equations are simultaneously estimated to yield consistent standard errors (Greene, 2008).[12] For more details, see equation (A1.4) (in the appendix).

[11] Note that IT outsourcing within a group of companies is not regarded as external outsourcing in this analysis.

[12] Estimation has been carried out with Stata® and the additional `movestay` command provided by Lokshin and Sajaia (2004).

The covariance terms $\sigma_{o,\epsilon}$ and $\sigma_{n,\epsilon}$ in equations (1.8) and (1.9) can be further split into $\sigma_{o,\epsilon} = \rho_{o,\epsilon}\sigma_0$ and $\sigma_{n,\epsilon} = \rho_{n,\epsilon}\sigma_n$.[13] The estimated correlation coefficients $\rho_{o,\epsilon}$ and $\rho_{n,\epsilon}$ also have an economic interpretation (Maddala, 1983; Fuglie and Bosch, 1995; Hamilton and Nickerson, 2003). If $\rho_{o,\epsilon}$ and $\rho_{n,\epsilon}$ have alternate signs, then firms source out IT services on the basis of their comparative advantage: those who source out have above-average returns from outsourcing and those who decide against outsourcing have above-average returns from non-IT outsourcing. On the other hand, if the coefficients have the same sign, this indicates hierarchical sorting: outsourcing firms have above-average returns regardless of their outsourcing decision, but they are doing better with outsourcing, whereas non-outsourcing firms have below-average returns in either case, but they are doing better without outsourcing.

Besides looking only at the point estimates of the two regime equations, I compare in a further step kernel density estimates of the conditional labour productivity distributions for IT outsourcing and non-IT outsourcing firms (see, for example, Bertschek and Kaiser, 2004). In detail, firms' labour productivity in the case of IT outsourcing is compared to the (hypothetical) labour productivity that firms would achieve if they did not make use of IT outsourcing. Vice versa, the labour productivity of firms without IT outsourcing is compared to the (hypothetical) labour productivity in the case that the firms make use of IT outsourcing. The productivity distributions are estimated conditional on the outsourcing decision of the firms to control for systematic differences between outsourcing and non-outsourcing firms. Further details of the calculations are presented in the appendix.

1.4 Data

The data for the empirical analysis stems from the ZEW ICT survey conducted in 2004, which is a representative computer-assisted telephone survey based on a stratified[14] random sample of about 19 000 German manufacturing and service firms.[15] About 4 440 firms participated in the survey, which corresponds to a response rate of approximately 23 percent. Among other things, survey participants were asked about their firms IT outsourcing behaviour. In detail, they had to state their outsourcing engagement in eight different IT service domains and additionally indicate the outsourcing intensity (in terms of partly

[13] Note that the variance of error term of the selection equation $\sigma_\epsilon = 1$. For further details, please refer to the appendix.

[14] The sample was stratified by sector affiliation (see Table A1.5 (in the appendix)), size class, and region, i.e. Western and Eastern Germany. Only firms with five and more employees were included in the survey.

[15] The source data was provided by *Creditreform*, Germany's largest credit rating agency.

or fully) in each of those services.[16] The ZEW ICT survey also contains very detailed information on the use of information and communication technologies (ICT) within the firm. Additionally, total sales, the number of employees and their skill structure, total investments, export share and various other *control* variables are available. The sector *electronic processing and telecommunication* is excluded from the estimation sample, due to the fact that firms offering IT services to others are predominantly classified in this sector. The outsourcing behaviour of IT outsourcing vendors is presumably very different compared to firms operating in other sectors and the rational for outsourcing there does not necessarily go in line with the theoretical argumentation for IT outsourcing sketched previously. Due to item-nonresponse and after conducting consistency checks, the estimation sample decreased to a total of 2 534 observations.[17]

As a measure of firm output, total sales in 2003 are available. Unfortunately, there is no further information on intermediate inputs at hand from the survey. Using sales as the output value in a production function framework (without having measures for intermediate inputs) might induce an omitted variable bias, since industries that operate at the end of the value chain (i.e. *wholesale* or *retail trade*) resort more strongly to intermediate goods than industries operating at an earlier stage (Schreyer and Pilat, 2001). To control for those differences, I calculated the shares of real value added at the NACE two-digit industry level.[18] The firm-specific values for total sales are then multiplied by those two-digit industry-specific shares.

Although the survey covered the whole range of IT services companies potentially need for running their business, asking further if the firms had partially or fully outsourced each specific activity to an external service provider, the empirical analysis is restricted to only *basic* IT services.[19] In detail, these are (i) *installation of new hardware and software*, (ii) *computer system maintenance* and (iii) *user assistance and support*. The reason for a restriction to basic IT services is that a lot of firms have (especially at the time the survey was conducted) no need for more sophisticated IT services, like e.g. *software*

[16] The IT service domains that were queried in the survey are *installation of new hardware and software*, *computer system maintenance*, *user assistance and support*, *software programming*, *web design and maintenance*, *IT training*, *IT security* and *application service providing*. At the time the survey was conducted, this list comprehensively summarises IT services required by firms.

[17] Checks for systematic differences in the anatomy of firms (with respect to firm size, sector affiliation, regional affiliation, investment and the share of employees working mainly at a computerised workplace) that have to be left out due to item-nonresponse, indicate that these firms are missing at random.

[18] The German Statistical Office is providing this data based on National Accounts.

[19] Notice again that this study is not specifically focusing on IT offshoring at all. A broader look is taken by not restricting IT outsourcing activities to service providers located abroad only.

programming or *web design and maintenance*, whereas the above-mentioned basic IT services are essential in every firm using information and/or computer technology in their business operations. Based on the survey information on those three basic IT services, a binary indicator was constructed to reflect overall basic IT outsourcing. This dummy variable takes the value of one if a firm outsources at least one basic IT service completely and is zero otherwise.[20]

The last column of Table 1.1 gives an overview of the IT outsourcing intensity by industry affiliation. Overall, slightly more than 39 percent of the firms are engaged in the outsourcing of basic IT services. In most industries, the intensity of outsourcing exceeds the mean value. The share of outsourcing firms in the *electrical engineering* and the *technical services* industry is substantially below the mean, with only 23 and 27 percent of firms. By contrast, *wholesale trade*, with 47 percent, is the industry with the highest outsourcing intensity.[21] Figure 1.1 displays the relative frequencies of IT outsourcing in relation to firm size. Since the outsourcing variable is binary, the relative frequencies are obtained by grouping the number of employees into eleven size classes. The size of the individual dots in Figure 1.1 reflects the number of firms in each group. For the four smallest size classes (up to 99 employees), the outsourcing intensity lies consistently between 40 and 50 percent. Starting with the size class of 100 to 249 employees, the frequency drops sharply and continues to fall to less than 15 percent of firms engaged in outsourcing in the class with 500 to 999 employees. For large firms (with more than 999 employees), again an increasing outsourcing frequency is observable. However, it has to be noted that the absolute number of firms in those classes is comparatively low, as indicated by the size of the dots.

Since the survey provides no data for the physical capital stock of the firms, I used, as in Bertschek and Kaiser (2004) and Bertschek et al. (2006), gross investment data as an empirical proxy for the capital stock. This approach could be a potential drawback for this study, but without sufficient panel data at hand, it is not possible to calculate the firms' capital stocks by means of the perpetual inventory method (see, for example, OECD, 2009). Unfortunately, a couple of firms in the original data set either have missing values for investments or report zero investments.[22] For the firms reporting zero investments, it seems reasonable to assume that investment is positive but low and therefore was

[20] There is a strong correlation between the binary variables of the three basic IT services (see Table A1.1 in the appendix), which indicates that the construction of a good (overall) basic IT outsourcing indicator out of those three outsourcing variables is reliable.

[21] Table 1.1 also gives an overview of the samples industry distribution (column one and two). The *metal and machine construction* industry shows the highest share in the sample, while *banks and insurances* together with *wholesale trade* have the lowest shares.

[22] With an econometric specification of the production function in logarithmic terms for factor inputs, these firms would have been excluded from the sample.

Table 1.1: Sample distribution and IT outsourcing distribution by industry

	Firms in sample		... thereof IT outsourcing	
Industry	**#**	**%**	**#**	**%**
consumer goods	243	9.6	106	43.6
chemical industry	147	5.8	59	40.1
other raw materials	224	8.8	92	41.1
metal and machine const.	311	12.3	120	38.6
electrical engineering	171	6.7	40	23.4
precision instruments	235	9.3	88	37.5
automobile	168	6.6	67	39.9
wholesale trade	129	5.1	61	47.3
retail trade	186	7.3	82	44.1
transport and postal serv.	192	7.6	79	41.2
banks and insurances	120	4.7	53	44.2
technical services	222	8.8	59	26.6
other business-related serv.	186	7.3	88	47.3
Total	2 534	100.0	994	39.2

Note: Number and share of firms involved in basic IT outsourcing in 2004 by industry affiliation.
Source: ZEW ICT survey 2004 and own calculations.

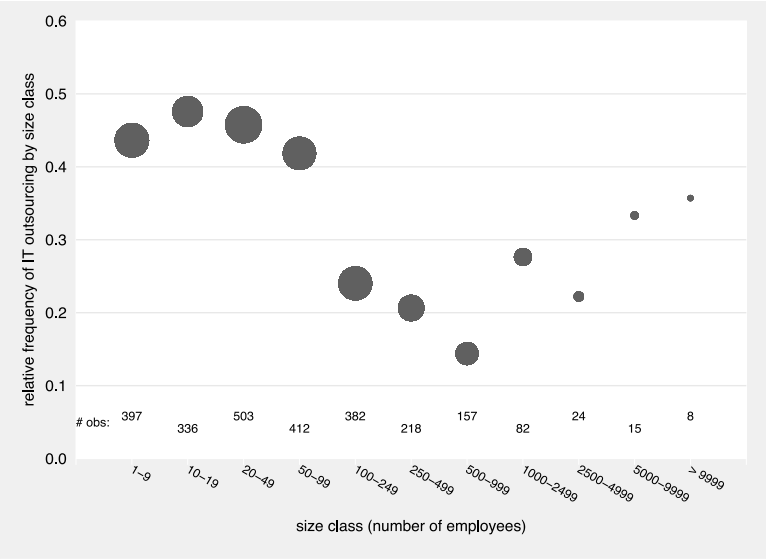
rounded to zero by the interviewee. To address this problem, the value of investment for those firms is set to the 10 percent quantile of their respective industry and size class. The investment value of firms with a missing value is replaced by the median value of the respective industry and size class.

Descriptive statistics are shown in Tables 1.2 and A1.2 (in the appendix). While the first table refers to the total sample, the second table shows descriptives separately for IT outsourcing and non-IT outsourcing firms. Most of the variables in the sample, including the quantitative variables *sales* respectively *value added*, *labour*[23] and *investment*, refer to the year or year-end of 2003. The information about *IT outsourcing*, *share of computer workplaces* and *IT applications* describe the state at the time the survey was conducted in 2004.

Mean *labour productivity* (measured as value added per full-time employee) for the whole sample is 87 757 euros with the median value being substantially lower at around 55 000 euros. With Table A1.2, it can easily be verify that

[23] Note that labour is measured in full-time equivalent terms. To calculate the adjusted numbers, it is assumed that each part-time employee works half the time of a full-time employee.

Figure 1.1: IT outsourcing versus firm size



Note: Size classes (in number of employees) versus the relative frequencies of IT outsourcing. The size of the dots indicates the number of firms in the considered interval.
Source: ZEW ICT survey 2004 and own calculations.

the mean labour productivity is higher in the IT outsourcing group, reaching a value of 93 906 euros as compared to 83 788 euros in the non-outsourcing group. This is a first indication that there might be significant differences in labour productivity between IT outsourcing and non-outsourcing firms. Mean investment (used as a proxy for the physical capital of the firm) is 2 885 332 euros in the total sample. Again, the investment level is above average in the outsourcing group. Regarding the size of the firms, outsourcing firms are, on average, smaller than non-outsourcing firms. While the mean size value for outsourcer is 224 employees, non-outsourcing firms have on average 320 employees. However, for both groups, the median number of employees is significantly lower. Overall, the average share of employees working predominantly at a computerised workplace is approximately 42 percent. Almost 23 percent of the sample firms are located in East Germany. A works council exists in 39 percent of the firms and only a small sub-sample of 14 percent operates a foreign subsidiary. The average export share amounts to 17 percent. Interestingly, those last two variables, which basically reflect the internationalisation of the firms, are smaller for IT outsourcing firms, although one would assume that firms tend more to outsource their information technology when they are exposed to international competition. The variables *share of university degree* and *share of vocational education* reflect the skill structure of the work force. The average amount of employees with the highest degree of education being a university degree is 19 percent. On average, 59 percent of the work force had completed a vocational

Table 1.2: Descriptive statistics (for all firms)

			Quantile			
Variable	**Mean**	**STD**	**10%**	**50%**	**90%**	**Dummy**
sales[♮]	75 561.32	486 202.05	600.00	7 000.00	100 000.00	no
value added	29 951.62	207 911.43	318.23	2 983.39	42 225.60	no
labour[◇]	282.23	1 180.52	7.00	50.00	530.00	no
investment[†]	2 885.33	22 352.71	12.00	200.00	5 000.00	no
value added/labour[§]	87.76	100.58	24.27	55.00	182.25	no
log(value added/labour)	4.118	0.782	3.189	4.007	5.205	no
log(labour)	4.016	1.668	1.946	3.912	6.273	no
log(investment)	5.466	2.211	2.485	5.298	8.517	no
share computer workplaces	0.429	0.312	0.100	0.330	1.000	no
IT outsourcing	0.392	0.488	–	–	–	yes
Y2K consulting	0.533	0.499	–	–	–	yes
East Germany	0.227	0.419	–	–	–	yes
share university degree	0.191	0.232	0.000	0.100	0.556	no
share vocational education	0.590	0.253	0.200	0.621	0.900	no
works council	0.391	0.488	–	–	–	yes
foreign subsidiary	0.135	0.342	–	–	–	yes
export share	0.166	0.245	0.000	0.025	0.600	no
age: 0-3 years	0.027	0.162	–	–	–	yes
age: 4-7 years	0.124	0.330	–	–	–	yes
# IT applications	2.537	1.692	1.000	2.000	5.000	no
Number of observations			2 534			

Note: All monetary variables are reported in 1 000 euros. [♮]Sales is measured as balance-sheet total for banks and insurance premium total for insurance companies. [◇]Labour is measured in full time equivalent units. [†]Investment is used as a proxy for capital. [§]Value added per employee (full time equivalent).
Source: ZEW ICT survey 2004 and own calculations.

education. At the time the survey was conducted (2004), most firms in the sample were older than seven years. Only 3 percent are as young as three years and 12 percent are between 3 and seven years old. The average amount of IT applications[24] employed by the firms is 2.5. All the above-mentioned variables differ (sometimes substantially) in the two subgroups of IT outsourcing and non-outsourcing firms. 53 percent of al firms were engaged in *Y2K consulting*, the identifying variable for the IT outsourcing decision (see Section 1.5.1 below). This value is substantially higher in the outsourcing group and amounts to 64 percent.

[24] The broad use of ten software and internet related computer applications, like customer relationship management (CRM) systems, enterprise resource planing (ERP) systems and business to business e-commerce (B2B) are subsumed in this variable.

1.5 Empirical Results

1.5.1 Selection Equation

Estimation results of the selection equation, referring to equation (1.6), are presented in the last two columns of Table 1.3. All variables of the labour productivity equation are included, and additionally, an identifying variable for the regime selection decision. The variable used for identification, as already mentioned, is a binary indicator that states whether the firm in question contracted out IT consulting or IT-services related to adjust the firms' information technology to the problems faced by the *Y2K Millennium Bug*.[25]

To make the switching regression model valid, the identifying variable in the selection equation has to be significant. This is the case, as can be seen by the highly significant positive coefficient of the Y2K consulting variable, reported in the selection equation columns of Table 1.3. The further explanatory variables show a somehow mixed picture concerning their significance, and, additionally, the direction of the effects does not always correspond to the one expected beforehand. One coefficient which his highly significant and, as expected, negative, is labour input. Larger firms are therefore less inclined to IT outsourcing. This certainly is in line with the economies of scale argument, which states that large firms can provide IT services themselves efficiently. The expected effect for the share of employees working at a computerised workplace was not clear at the beginning. It now shows that the share of computer workplaces has a significantly negative effect on IT outsourcing. The same is true for the share of employees with a university degree. Albeit the coefficient for works councils is negative, as expected, the effect is not significant. This is surprising, because I assumed a significantly negative effect of works councils for all outsourcing decisions, since employee representatives do not want to loose control over processes so far conducted in-house. Firms that are exposed to international competition are assumed to outsource more to increase their competitiveness. Both variables measuring internationalisation, the existence of a foreign subsidiary and the share of exports, show a negative sign, with the export share not being significant. An explanation for the negative and significant coefficient for foreign subsidiary could be the better availability of IT resources within a group of firms. Those firms might also be directly provided with IT services from the foreign location (which is not considered as outsourcing in the survey) and therefore renders outsourcing for them unnecessary. Young firms, less than four years old, are less likely to outsource. This seems very plausible, since in the foundation stage, various other challenges have to be mastered.

[25] See also the lengthy explanation and discussion of this variable in Section 1.3.

Table 1.3: Endogenous switching regression estimation results

	Productivity Equation				Selection Equation	
	w/ IT outs.		w/o IT outs.			
	Coeff.	*SE*	*Coeff.*	*SE*	*Coeff.*	*SE*
log(labour)	-0.1206***	(0.0291)	-0.0793***	(0.0250)	-0.1130***	(0.0348)
log(investment)	0.0958***	(0.0175)	0.1112***	(0.0163)	-0.0203	(0.0220)
share computer workplaces	0.9174***	(0.1082)	0.4703***	(0.0858)	-0.3513***	(0.1146)
East Germany	-0.3421***	(0.0533)	-0.2873***	(0.0450)	0.1695***	(0.0637)
share university degree	0.4108**	(0.1809)	0.5018***	(0.1345)	-0.5452***	(0.1876)
share vocational education	0.3028***	(0.1065)	0.1942**	(0.0941)	0.0411	(0.1347)
works council	0.1370**	(0.0607)	0.1378***	(0.0486)	-0.0971	(0.0738)
foreign subsidiary	0.2189**	(0.0868)	0.1896***	(0.0521)	-0.1744*	(0.0915)
export share	0.4522***	(0.1149)	0.2713***	(0.0733)	-0.1250	(0.1330)
age: 0-3 years	-0.1631	(0.1788)	0.0694	(0.0993)	-0.3485**	(0.1647)
age: 4-7 years	-0.0454	(0.0616)	0.0105	(0.0560)	0.1116	(0.0818)
# IT applications	0.0400***	(0.0145)	0.0369***	(0.0126)	0.0066	(0.0176)
Y2K consulting					0.4917***	(0.0724)
constant	3.3695***	(0.1298)	2.7622***	(0.1505)	0.3060*	(0.1587)
σ_o^2 or σ_n^2	0.6704***	(0.0202)	0.7125***	(0.0425)		
$\rho_{o,\epsilon}$ or $\rho_{n,\epsilon}$	-0.2367**	(0.1120)	-0.7309***	(0.0956)		
industry dummies	yes		yes		yes	
number of observations	1 540		994		2 538	

Note: Dependent variable for the productivity equation is log(value added/labour) and for the selection equation it is basic IT outsourcing. *,** and *** indicate significance at the 10%, 5% and 1% level respectively. Robust standard errors are shown in parentheses. **Source:** ZEW ICT survey 2004 and own calculations.

In Table A1.3 (in the appendix), Wald-tests for the joint significance of various subgroups of the variables in the selection equation are shown. The factor inputs (labour and capital, proxied by investment) are jointly significant. But also the set of all other explanatory variables (without identifier and sector dummies) are together highly significant. Contrary, the sector dummies altogether display no significant effect. A test for joint significance of the entire selection equation is highly significant ($\chi^2 = 256.28$; *p*-value $= 0.0000$), indicating that the decision to source out IT services is influenced by productivity differences. Altogether, this suggests that the chosen exclusion restrictions are valid and hence, the entire model is valid, as well.

1.5.2 Productivity Equations

The estimation results of the two regime equations—firms with IT outsourcing and firms without IT outsourcing—are presented in columns 6 to 9 of Table 1.3. In line with the model described in Section 1.3, the dependent variable *labour productivity*, as well as the variables for the factor inputs *capital* and *labour* are transformed into their logarithmic values for estimation. To compare the coefficients of the two regimes, Wald-tests for identity of the coefficients are carried out. The results are shown in Table 1.4.

Table 1.3 also contains the correlation coefficients ($\rho_{o,\epsilon}$ and $\rho_{n,\epsilon}$) between the error term of the selection equation and the labour productivity equations for IT outsourcing firms (o) and non-IT outsourcing firms (n), respectively. To check whether the IT outsourcing decision is endogenous, it has to be tested if $\rho_{o,\epsilon}$ and $\rho_{n,\epsilon}$ are statistically different from zero. If $\rho_{o,\epsilon}$ and $\rho_{n,\epsilon}$ are zero, then the selection into the IT outsourcing regime is exogenous, therefore it would not be necessary to model and include a selection equation to estimate the impact of IT outsourcing on labour productivity. As can easily be observed, both correlation coefficients are negative and individually significant. Furthermore, specification tests confirm that these coefficients are also jointly statistically significant (see last row of Table A1.4 in the appendix). Thus, IT outsourcing can not be treated as truly exogenous and it is necessary to account for selectivity in each of the regime equations.

Since both correlation coefficients are negative, this implies that in the outsourcing regime, firms with a higher probability of IT outsourcing tend to make smaller productivity gains when they are involved in IT outsourcing. In the non-outsourcing regime, firms with a higher propensity to outsource would make productivity gains even if they did not actually outsource.[26] If it is not accounted for unobserved heterogeneity, the labour productivity of IT outsourcing

[26] Note that the inverse Mill's ratio $-[\phi(\boldsymbol{Z_i\pi})/(1-\Phi(\boldsymbol{Z_i\pi}))]$ is always negative and the estimated coefficient $\rho_{n,\epsilon}$ is also negative. Therefore, the resulting effect is positive.

firms would be overestimated. On the other side, without accounting for unobserved heterogeneity, an underestimation of labour productivity for non-IT outsourcing firms would be the case.

Let us turn to the interpretation of the main productivity regression results. There is a highly significant and positive effect with regard to the two factor inputs, labour and investment, and the share of computer workers on labour productivity in both regimes.[27] The partial elasticities for labour and investment are slightly higher in the regime without outsourcing activities but according to the Wald-test results in Table 1.4, identity cannot be rejected at the usual significance levels. For the share of employees working with a computer, the estimated coefficients are both highly significant, being substantially higher in the IT outsourcing case.[28] The calculation of the partial output elasticities[29] and their comparison via Wald-test results in a significant difference of those elasticities. In addition, the value of the elasticity in the outsourcing regime is substantially higher. Therefore, there is empirical evidence that employees working at a computerised workplace in firms involved in IT outsourcing are more efficient. The share of computer employees and IT outsourcing can be interpreted as complementary factors which positively affect firms' labour productivity.

The sum of the two input elasticities (investment and labour) amounts to 0.9752 in the regime with IT outsourcing and to 1.0319 in the regime without IT outsourcing. In the first case, the null hypothesis of constant returns to scale can not be rejected (Wald-test: $\chi 2 = 1.20$; *p*-value $= 0.2733$). For non-IT outsourcing firms, on the other hand, the constant returns to scale hypothesis can only be rejected weakly (Wald-test: $\chi 2 = 2.97$; *p*-value $= 0.0848$). A test for identical returns to scale for the two regimes then also results in a rejection, albeit on a weak significance level (Wald-test: $\chi 2 = 3.9495$; *p*-value $= 0.0469$).

The measures of the qualification structure of the work force, *university degree* and *vocational education*, as well as the existence of a *works council*, the variable indicating whether the firm has *foreign subsidiaries* and the *export share* have all a significantly positive effect on labour productivity in both regimes. However, in all those cases, the differences between the two regimes are not statistically significant. In both regimes, the variable reflecting the amount of innovative software and internet applications (*# IT applications*) launched by the

[27] Note that the estimated coefficients for the labour input correspond to $(\gamma - 1)$. Adding one to the estimated coefficient yields the partial output elasticity of labour.

[28] Note that the coefficient is equal to labour efficiency times labour elasticity.

[29] The partial output elasticity for the share of computer workers, which is equal to the difference in relative labour efficiency between computer and non-computer employees, is 1.0432 $[= 0.9174/(-0.1206 + 1)]$ in the IT outsourcing regime and 0.5108 $[= 0.4703/(-0.0793 + 1)]$ in the non-IT outsourcing regime.

Table 1.4: Wald test for identity of the coefficients in the productivity equation

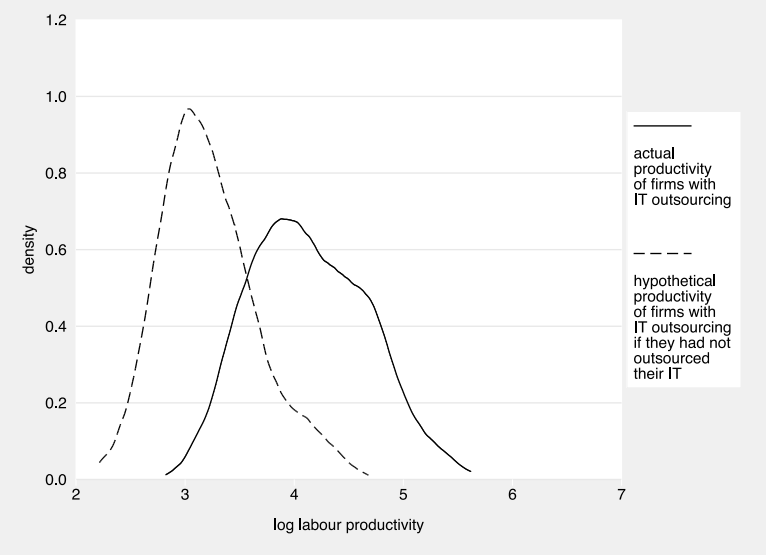
	χ^2	***p*-value**
log(labour)	1.2243	0.2685
log(investment)	0.4210	0.5164
share computer workplaces†	12.3655	0.0004
East Germany	0.6463	0.4214
share university degree	0.1702	0.6799
share vocational education	0.6161	0.4325
works council	0.0001	0.9918
foreign subsidiary	0.0869	0.7681
export share	1.8870	0.1695
age: 0-3 years	1.3768	0.2406
age: 0-7 years	0.4775	0.4895
# IT applications	0.0257	0.8727
constant	9.6169	0.0019
Set of input factors††	4.3918	0.1113
Set of other factors†††	20.9411	0.0215
Set of sector dummies	15.8912	0.1963
Entire specification	73.8946	0.0000

Note: †For the share of computer workplaces, the partial output elasticities between the two regimes (γ_o and γ_{no}) are compared. In this case, the *p*-value calculation is based on the delta method, an approximation which is appropriate in large samples. ††Input factors include labour and investment (as a proxy for capital). †††Other factors include the variables *East Germany*, *university degree* and *vocational education*,*works council*, *foreign subsidiary*, *export share*,*age*, and *# IT applications*.
Source: ZEW ICT survey 2004 and own calculations.

firm is positive and highly significant, although once more, there is no statistical difference between the regimes observable. *Firm age* dummies are insignificant in both regimes. The dummy variable that indicates whether a firm is located in East Germany has significant and negative coefficients, which reflects lower labour productivity in East Germany. Some, but not all of the industry dummies, are significant (the base category is *metal and machine construction*). In this setting, the coefficients of the sector dummies have no specific economic meaning. They rather control for different measurements of labour productivity and other factors across industries. Additionally, as stated in the bottom part of Table 1.4, a Wald-test for identity of the factor inputs (*labour* and *investment*) cannot be rejected, whereas the identity of the other variables included in the estimation, as well as the identity of the entire specification can be rejected.

An important result refers to the constant terms in both productivity regimes, which reflects multi-factor productivity in a production function framework. In

Figure 1.2: Changes in the conditional log labour productivity distribution due to IT outsourcing: what if firms with IT outsourcing had not outsourced their IT?



Source: ZEW ICT survey 2004 and own calculations.

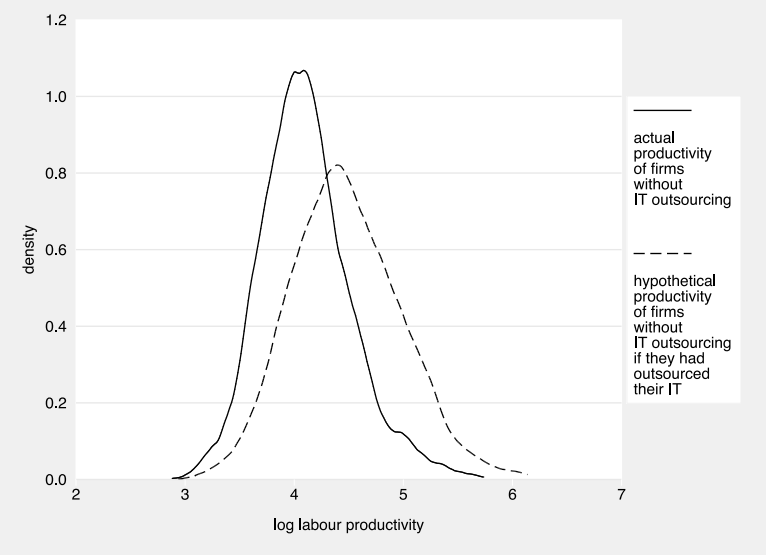
both regimes, the constant term is significant, but it is significantly larger in the IT outsourcing regime. This implies that firms being involved in IT outsourcing produce in general more efficiently than firms that do not outsource.

To visualise the joint effects of the differences in the partial output elasticities for IT outsourcing and non-IT outsourcing firms and the firm heterogeneity parameters, kernel density estimates of the conditional log labour productivity distributions in the two regimes are compared. The results are displayed in Figures 1.2 and 1.3. These figures show the joint productivity effects of IT outsourcing arising from changes in the output elasticities of the input factors and from the changes in the observable firm heterogeneity parameters. In addition, the selectivity effect resulting from the firms' decision whether or not to outsource IT services is taken into account. The idea behind the figures is to consider the same firms—those with IT outsourcing (Figure 1.2) and those without IT outsourcing (Figure 1.3)—under the two different outsourcing regimes. In order to control for the fact that firms with IT outsourcing might be systematically different from those without IT outsourcing and thus might differ in their decision to engage in IT outsourcing, the productivity distributions are estimated conditionally on the IT outsourcing decision of the firms.[30]

The solid curve in Figure 1.2 represents kernel density estimates for log labour productivity related to the parameter vector with IT outsourcing and firms which actually conduct IT outsourcing, while the dashed curve corresponds to the

[30] Details on the calculations are displayed in equations (A1.6) and (A1.8) in the appendix.

Figure 1.3: Changes in the conditional log labour productivity distribution due to IT outsourcing: what if firms without IT outsourcing had outsourced their IT?



Source: ZEW ICT survey 2004 and own calculations.

parameter vector without IT outsourcing and firms which engaged in IT outsourcing.[31] In both figures, the log labour productivity distribution with IT outsourcing is located to the right of the regime without IT outsourcing. However, the productivity differentials in the log labour productivity between the two regimes are larger for firms which are actually involved in IT outsourcing. This means that the firms with IT outsourcing are clearly better off compared to the hypothetical case without IT outsourcing. On the other hand, those firms without IT outsourcing would not have gained that much if they had actually outsourced their IT (although the difference is still significant, see below for more details). Thus, it seems that on average, the firms make "the right decision" with respect to IT outsourcing since IT outsourcing is more profitable for firms that actually decided to do it.

To validate the presented graphical findings for the conditional distributions of log labour productivity presented in Figures 1.2 and 1.3, *t*-tests are conducted for the difference in mean log labour productivity between outsourcing (non-outsourcing) firms and their hypothetical situation without (with) outsourcing. Table 1.5 displays the corresponding test results. The mean log labour productivity of firms that are actually engaged in IT outsourcing turns out to be

[31] The solid curve in Figure 1.2 is calculated from the fitted values $\boldsymbol{V_i}\hat{\boldsymbol{\delta}}_{\boldsymbol{o}}$, while the dashed curve is calculated from the fitted values $\boldsymbol{V_i}\hat{\boldsymbol{\delta}}_{\boldsymbol{n}}$, where $\boldsymbol{V_i}$ includes only those firms with IT outsourcing, plus the selectivity parameter resulting from the choice of the firms whether or not to engage in IT outsourcing, respectively.

Table 1.5: Differences in conditional log labour productivity distributions

	Mean difference✠	**SE**	***p*-value**
IT outsourcing firms	0.9209 ⊛	0.0065	0.0000
non-IT outsourcing firms	0.3693 ⊛⊛	0.0048	0.0000

Note: ✠ The mean difference describes average changes in log labour productivity due to IT outsourcing. ⊛ IT outsourcing firms' mean difference in log labour productivity between the situation with IT outsourcing and the (counterfactual) situation without IT outsourcing, conditioned upon the firms outsourcing choice, respectively (see equation (A1.6) in the appendix and Figure 1.2). ⊛⊛ Non-IT outsourcing firms mean difference in log labour productivity between the (counterfactual) situation with IT outsourcing and the situation without IT outsourcing, conditioned upon the firms outsourcing choice, respectively (see equation (A1.8) (in the appendix) and Figure 1.3).
Source: ZEW ICT survey 2004 and own calculations.

significantly higher compared to the hypothetical mean log labour productivity for the case that these firms did not source out their IT. Firms that have already outsourced IT have, for instance, reorganised management responsibilities and other business processes allowing a more efficient production process, such that an abandonment of IT outsourcing would cause a tremendous drop in the firms' productivity. Non-IT outsourcing firms would also be better off if they outsourced their IT services. However, the hypothetical gain in productivity non-IT outsourcing firms would realise is smaller than the hypothetical loss in productivity for firms that currently are involved in IT outsourcing.

Interestingly, the unconditional mean difference between the estimated and the hypothetical labour productivity is nearly the same for firms with and without IT outsourcing (the first summands in equations (A1.6) and (A1.8)). If non-IT outsourcing firms were supposed to produce according to the production function of firms in the regime with IT outsourcing, thus implicitly assuming that non-IT outsourcing firms made equivalent organisational adjustments or acquired equivalent organisational resources like firms in the regime with IT outsourcing, non-IT outsourcing firms would realise a considerable gain in labour productivity. However, due to the selection into the regime without IT outsourcing (the second summands in equations (A1.6) and (A1.8)), the conditional mean difference in labour productivity is smaller. One possible explanation might be that firms selected into the regime without IT outsourcing do so because they expect that the costs involved with IT outsourcing would not be sufficiently outweighed by productivity gains (see equation (1.6)). Therefore, the higher gain in productivity for firms with IT outsourcing is a result of the selection in the regime with IT outsourcing.

1.6 Summary and Concluding Remarks

The aim of this chapter is to analyse the effects of IT outsourcing on labour productivity. In recent years, the demand for external service providers to run and support firms' information technology infrastructure is a widely observed phenomenon. The question at hand is whether this external supply has any productivity enhancing effect for the outsourcing firm. The central theoretical arguments behind this empirical research goes back to the core competencies considerations of the outsourcing firm. IT outsourcing frees management capacity which in turn can be used to focus on a firms main business. Processes can be improved and innovations can be fostered. Additionally, because of economies of scale on the vendor side, it is widely accepted that external providers can offer IT services cheaper than in-house departments. This helps firms to save production costs.

The relationship between IT outsourcing and firms' labour productivity is examined using an *endogenous switching regression model* which divides firms into two regimes, IT outsourcing and non-IT outsourcing firms. This method allows IT outsourcing to affect the productivity elasticities of the input factors differently in both groups. Moreover, it takes account of potential simultaneity between the decision to source out IT and the firms' labour productivity. For the analysis, German firm-level data from a comprehensive survey conducted in 2004 in manufacturing and selected service industries with more than five employees is utilised.

The use of an endogenous switching regression model to account for the simultaneity between IT outsourcing and labour productivity seems to be justified due to the jointly and individually significant correlation parameter between each of the two productivity equations and the selection equation. The estimation results show that firms which are actively outsourcing IT services have a significantly higher production efficiency as measured by the constant term compared to firms not involved in IT outsourcing. The second important result of this study refers to the difference in the contribution of employees working at a computerised workplace to labour productivity in the two regimes. The partial output elasticities are both positive, but significantly larger in the regime with IT outsourcing. This result hints at a positive complementarity between IT outsourcing and the share of employees working at a computerised workplace. Together, both factors affect labour productivity positively. Summarising the results, I could find evidence for a positive impact of IT outsourcing on firm performance in terms of a higher overall efficiency of IT outsourcing firms and a significantly higher productivity of employees working with a computer in IT outsourcing firms. With an continuously increasing share of computer users

in firms,[32] this result is particularly important, since firms can improve their performance significantly by relying on external service providers to run their IT services.

There are a couple of questions which remain unanswered, being a starting point for future research. First of all, the analysis in this chapter only considers basic IT service outsourcing. Further research could concentrate on the outsourcing effects of specialised IT services. From a theoretical point of view, the direction of the effect is not clear. It might be negative in case too much decision power concerning core processes of the firm is given out of hand to an external provider. This would be especially true whenever it is not possible to make sufficient and complete contractual arrangements. Secondly, because of data restrictions, it is not possible to consider the amount of IT outsourcing in monetary terms. I tried to solve this remedy by the inclusion additional variables controlling for IT intensity. Nevertheless, it would be desirable to conduct this analysis with richer data on IT outsourcing at hand. And last, as shown in Figure A1.2, IT offshoring, i.e. outsourcing to a foreign service provider, has gained importance in recent years. For future research, it might be interesting to differentiate between local IT outsourcing and IT offshoring, if appropriate data is available.

[32] Note that the share of employees working with a computer rose almost continuously from 51 percent in 2002 to 62 percent in 2009 according to data referring to the ICT survey conducted by the German Statistical Office.

1.7 Appendix

1.7.1 Methodology

Expected value of the truncated error terms

Regarding the variances of the error terms in the two regime equations, σ_o^2 and σ_n^2 (see Equations (1.4) and (1.5)), and the variances of the error term of the selection equation, σ_ϵ^2 (see Equation (1.6)), I assume according to Maddala (1983) that $(u_{i,o},\ u_{i,n},\ \epsilon_i)$ is trivariate normally distributed with mean zero and a non-singular covariance matrix Σ specified as

$$\boldsymbol{\Sigma} = \text{cov}(u_o, u_n, \epsilon) \ = \ \begin{pmatrix} \sigma_o^2 & \sigma_{o,n} & \sigma_{o,\epsilon} \\ & \sigma_n^2 & \sigma_{n,\epsilon} \\ & & \sigma_\epsilon^2 (= 1) \end{pmatrix}. \tag{A1.1}$$

$\sigma_{o,\epsilon}$ is a covariance between the error term of the outsourcing regime, $u_{i,o}$, and the selection equation, ϵ_i, and $\sigma_{n,\epsilon}$ is a covariance for the case of the non-outsourcing regime. The covariance between $u_{i,o}$ and $u_{i,n}$ is not defined since the two regimes are never observed simultaneously. Since $\boldsymbol{\pi}$ can only be estimated up to a scale factor, it is convenient to assume that $\sigma_\epsilon^2 = 1$. Given these assumptions, the expected values of the truncated error terms $(u_{i,o}|I = 1)$ and $(u_{i,n}|I = 0)$ are:

$$\begin{aligned} E[u_{i,o}|I = 1] &= E[u_{i,o} \mid \epsilon_i \ > \ -\boldsymbol{Z_i\pi}] \\ &= \sigma_{o,\epsilon} \left(\frac{\phi(\boldsymbol{Z_i\pi})}{\Phi(\boldsymbol{Z_i\pi})} \right) \\ &= \sigma_{o,\epsilon}\ \lambda_{i,o}\ , \end{aligned} \tag{A1.2}$$

$$\begin{aligned} E[u_{i,n}|I = 0] &= E[u_{i,n} \mid \epsilon_i \ \leq \ -\boldsymbol{Z_i\pi}] \\ &= \sigma_{n,\epsilon} \left(\frac{-\phi(\boldsymbol{Z_i\pi})}{1 - \Phi(\boldsymbol{Z_i\pi})} \right) \\ &= \ -\ \sigma_{n,\epsilon}\ \lambda_{i,n}\ , \end{aligned} \tag{A1.3}$$

where $\phi(\cdot)$ and $\Phi(\cdot)$ represent the density and distributional function of the standard normal. The terms $\sigma_{o,\epsilon}$ and $\sigma_{n,\epsilon}$ measure the covariance between the error terms of the production function and the selection equation.

Full Information Maximum Likelihood (FIML) estimator

Given the assumption of trivariate normal distribution for the error terms, the logarithmic likelihood function for the system of Equations (1.4), (1.5) and (1.6) is given by:

$$\begin{aligned}
\ln L = \sum_{i=1}^{N} \Bigg\{ I_i \Bigg[\ln\Phi \left(\frac{\boldsymbol{Z_i\pi} + (\rho_{o,\epsilon}/\sigma_o)\left(\ln(Y_i/L_i)_o - \boldsymbol{V_i\delta_o}\right)}{\sqrt{1-\rho_{o,\epsilon}^2}} \right) \\
- \ln\left(\sqrt{2\pi}\sigma_o\right) - \frac{1}{2}\left(\frac{\ln\left(\frac{Y_i}{L_i}\right)_o - \boldsymbol{V_i\delta_o}}{\sigma_o} \right)^2 \Bigg] \\
+ (1-I_i) \Bigg[\ln\left(1 - \Phi\left(\frac{\boldsymbol{Z_i\pi} + (\rho_{n,\epsilon}/\sigma_n)\left(\ln(Y_i/L_i)_n - \boldsymbol{V_i\delta_n}\right)}{\sqrt{1-\rho_{n,\epsilon}^2}} \right) \right) \\
- \ln\left(\sqrt{2\pi}\sigma_n\right) - \frac{1}{2}\left(\frac{\ln\left(\frac{Y_i}{L_i}\right)_n - \boldsymbol{V_i\delta_n}}{\sigma_n} \right)^2 \Bigg] \Bigg\} \qquad \text{(A1.4)}
\end{aligned}$$

where Φ is the cumulative distribution function of the standard normal distribution, $\rho_{o,\epsilon} = \sigma_{o,\epsilon}/\sigma_o$ is the coefficient of correlation between u_o and ϵ (note that by definition $\sigma_\epsilon = 1$) and $\rho_{n,\epsilon} = \sigma_{o,\epsilon}/\sigma_o$ is the coefficient of correlation between u_n and ϵ.

Conditional comparison of labour productivity

The estimated productivity differentials for firms that decided to source out IT ($PD_{i,o}$) can be stated as follows:

$$PD_{i,o} = E\left[\ln\left(\frac{Y_i}{L_i}\right)_o \;\middle|\; \boldsymbol{V_i},\ I=1 \right] - E\left[\ln\left(\frac{Y_i}{L_i}\right)_n \;\middle|\; \boldsymbol{V_i},\ I=1 \right] \qquad \text{(A1.5)}$$

$$= \left[\boldsymbol{V_i\delta_o} + \sigma_{o,\epsilon}\left(\frac{\phi(\boldsymbol{Z_i\pi})}{\Phi(\boldsymbol{Z_i\pi})} \right) \right] - \left[\boldsymbol{V_i\delta_n} + \sigma_{n,\epsilon}\left(\frac{\phi(\boldsymbol{Z_i\pi})}{\Phi(\boldsymbol{Z_i\pi})} \right) \right]$$

$$= \boldsymbol{V_i(\delta_o - \delta_n)} + (\sigma_{o,\epsilon} - \sigma_{n,\epsilon})\lambda_{i,o}, \qquad \text{(A1.6)}$$

where the first term in Equation (A1.5) represents the conditional expected labour productivity of firms that are actually engaged in IT outsourcing and the second term represents the conditional expected labour productivity of the same firms but for the hypothetical case that they had not chosen to do IT outsourcing. In other words, $E\left[\ln\left(Y_i/L_i\right)_o|\boldsymbol{V_i}, I=1\right]$ and $E\left[\ln\left(Y_i/L_i\right)_n|\boldsymbol{V_i}, I=1\right]$ represent, respectively, the average of outsourcing firms' actual labour productivity with IT outsourcing and the average of their counterfactual labour productivity without IT outsourcing. The difference $PD_{i,o}$ therefore provides a measure of the impact of IT outsourcing on labour productivity of firms who actually chose to outsource IT. $PD_{i,o} > 0$ (or $PD_{i,o} < 0$) would indicate a positive (or negative) impact of IT outsourcing.

The term $\boldsymbol{V_i(\delta_o - \delta_n)}$ in Equation (A1.6) represents the unconditional expected value of the log labour productivity differential, depending on the estimated coefficients, i.e. due to varying production elasticities in the two regimes. The second term $(\sigma_{o,\epsilon} - \sigma_{n,\epsilon}\lambda_{i,o}$ represents the impact of the firms' selection on the use of IT outsourcing where $\lambda_{i,o}$ is the inverse of Mill's ratio.

In the opposite case, the estimated productivity differentials for firms that decided not to source out IT ($PD_{i,n}$) can be stated as follows:

$$PD_{i,n} = E\left[\ln\left(\frac{Y_i}{L_i}\right)_o \;\middle|\; \boldsymbol{V_i},\ I=0\right] \;-\; E\left[\ln\left(\frac{Y_i}{L_i}\right)_n \;\middle|\; \boldsymbol{V_i},\ I=0\right] \tag{A1.7}$$

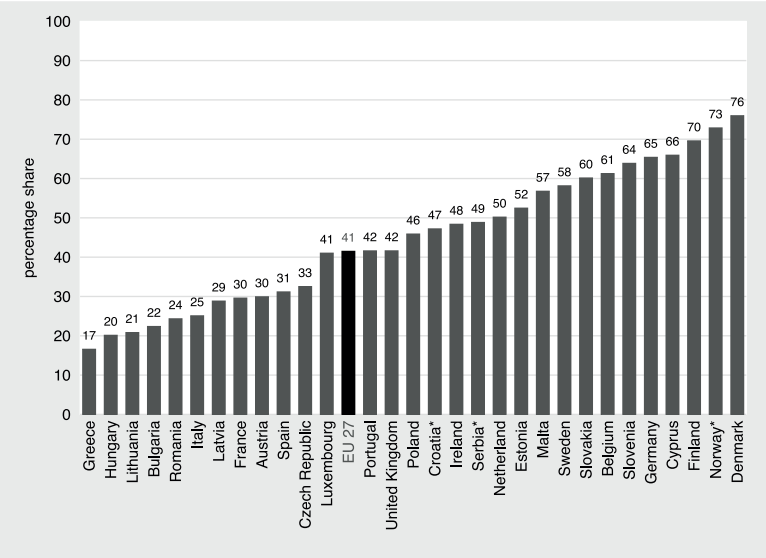
$$= \left[\boldsymbol{V_i\delta_o} \;-\; \sigma_{o,\epsilon}\left(\frac{\phi(\boldsymbol{Z_i\pi})}{1-\Phi(\boldsymbol{Z_i\pi})}\right)\right] \;-\; \left[\boldsymbol{V_i\delta_n} \;-\; \sigma_{n,\epsilon}\left(\frac{\phi(\boldsymbol{Z_i\pi})}{1-\Phi(\boldsymbol{Z_i\pi})}\right)\right]$$

$$= \boldsymbol{V_i(\delta_o - \delta_n)} \;-\; (\sigma_{o,\epsilon} - \sigma_{n,\epsilon})\lambda_{i,n}. \tag{A1.8}$$

Here, the first term in Equation (A1.7) represents the conditional expectation of non-IT outsourcing firms' labour productivity *with* IT outsourcing and the second term represents the conditional expectation of non-IT outsourcing firms' labour productivity *without* IT outsourcing. In other words, $E\left[\ln\left(Y_i/L_i\right)_o|\boldsymbol{V_i}, I=0\right]$ and $E\left[\ln\left(Y_i/L_i\right)_n|\boldsymbol{V_i}, I=0\right]$ represent, respectively, the average of non-outsourcing firms' hypothetical labour productivity with IT outsourcing and the average of their actual labour productivity without IT outsourcing. The difference $PD_{i,n}$ therefore provides a measure of the impact of IT outsourcing on labour productivity of firms who actually chose not to outsource IT. $PD_{i,n} > 0$ (or $PD_{i,n} < 0$) would indicate a positive (or negative) impact of IT outsourcing.

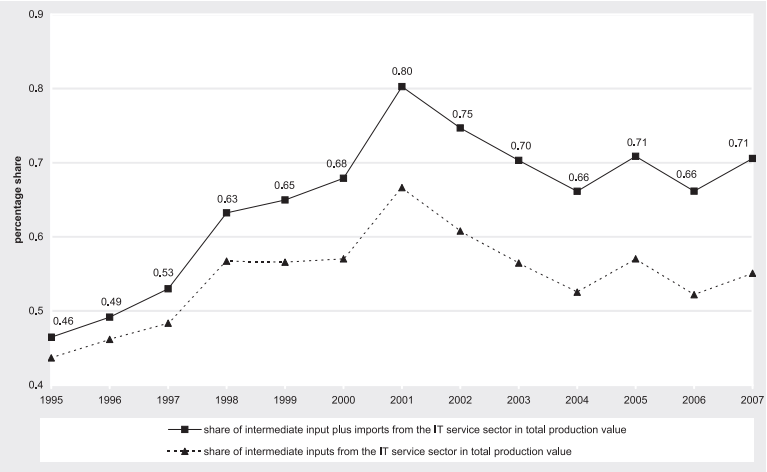
1.7.2 Tables and Figures

Figure A1.1: Outsourcing of IT services in the European Union in 2006



Note: Enterprises with at least 10 employees where ICT functions requiring ICT/IT specialists were performed (fully or partly) by external suppliers, during 2006. Financial sector is not included because of data comparability. *Included in the Eurostat statistic but not member of the EU 27. **Source:** ICT in enterprises statistics, Eurostat, 2006.

Figure A1.2: Share of intermediate IT input in total production value (Germany, 1995-2007)



Note: Services that were provided by the sector "Computer and related activities" which corresponds to NACE 72. **Source:** German Statistical Office and own calculations.

Table A1.1: Correlations

			Outsourcing of:		
	IT outsourcing	Y2K consulting	hard- and software installation	computer system maintenance	user assistance and support
IT outsourcing	1.0000				
Y2K consulting	0.1741 (0.0000)	1.0000			
Outsourcing of:					
hard- and software installation	0.7489 (0.0000)	0.1559 (0.0000)	1.0000		
computer system maintenance	0.8678 (0.0000)	0.1603 (0.0000)	0.6246 (0.0000)	1.0000	
user assistance and support	0.6228 (0.0000)	0.1346 (0.0000)	0.5307 (0.0000)	0.6015 (0.0000)	1.0000

Note: Table is based upon 2 534 observations. *p*-values for the level of significance are reported in parentheses.
Source: ZEW ICT survey 2004 and own calculations.

Table A1.2: Descriptive statistics (for IT and non-IT outsourcing firms)

	IT outsourcer		non-IT outsourcer	
Variable	**Mean**	**STD**	**Mean**	**STD**
sales[♮]	64 275.04	435 187.67	82 846.11	516 467.67
value added	24 559.67	150 164.69	33 431.88	237 836.34
labour[♢]	223.89	1 231.64	319.90	1 145.15
investment[†]	3 405.80	33 991.18	2 549.40	8 750.44
value added/labour[§]	93.91	108.45	83.79	94.97
log(value added/labour)	4.134	0.848	4.107	0.737
log(labour)	3.645	1.515	4.256	1.717
log(investment)	5.005	2.123	5.763	2.216
share computer workplaces	0.385	0.307	0.458	0.312
Y2K consulting	0.641	0.480	0.463	0.499
East Germany	0.266	0.442	0.202	0.402
share university degree	0.150	0.200	0.217	0.247
share vocational education	0.627	0.251	0.566	0.251
works council	0.302	0.459	0.449	0.498
foreign subsidiary	0.075	0.264	0.173	0.379
export share	0.130	0.220	0.189	0.257
age: 0-3 years	0.020	0.140	0.031	0.174
age: 4-7 years	0.134	0.341	0.118	0.322
# IT applications	2.344	1.724	2.662	1.660
Number of observations	994		1 540	

Note: All monetary variables are reported in 1 000 euros. [♮]Sales is measured as balance-sheet total for banks and insurance premium total for insurance companies. [♢]Labour is measured in full time equivalent units. [†]Investment is used as a proxy for capital. [§]Value added per employee (full time equivalent).
Source: ZEW ICT survey 2004 and own calculations.

Table A1.3: Wald test for joint significance of the selection equation coefficients

	χ^2	***p*-value**
factor inputs	27.5997	0.0000
set of other explanatory variables (w/o identifier and sector dummies)	62.3765	0.0000
sector dummies	17.7460	0.1236
entire productivity equation variables	44.2976	0.0000
entire selection equation	256.2813	0.0000

Source: ZEW ICT survey 2004 and own calculations.

Table A1.4: Wald test for joint significance of the entire switching regression estimation

	χ^2	***p*-value**
entire switching regression	31 419.7077	0.0000
correlation coefficients	12.4578	0.0020

Source: ZEW ICT survey 2004 and own calculations.

Table A1.5: Industry classification

Industry	Explanation	NACE
consumer goods		
	manufacture of food products, beverages and tobacco	15-16
	manufacture of textiles and textile products	17-18
	manufacturing of leather and leather products	19
	manufacture of wood and wood products	20
	manufacturing of pulp, paper and paper products; publishing and printing	21-22
	manufacturing n.e.c.	36-37
chemical industry		
	manufacture of coke, refined petroleum products and nuclear fuel	23
	manufacture of chemicals, chemical products and man-made fibres	24
other raw materials		
	manufacture of rubber and plastic products	25
	manufacture of non-metallic mineral products	26
	manufacture of basic metal	27
metal and machine construction		
	manufacture of fabricated metal products (except machinery and equipment)	28
	manufacture of machinery and equipment n.e.c.	29
electrical engineering		
	manufacture of office machinery and computers	30
	manufacture of electrical machinery and apparatus n.e.c.	31
	manufacture of radio, television and communication equipment and apparatus	32
precision instruments		
	manufacture of medical, precision and optical instruments, watches and clocks	33
automobile		
	manufacturing of transport equipment	34-35
wholesale trade		
	wholesale trade and commission trade (except of motor vehicles and motorcycles)	51
retail trade		
	sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	50
	retail trade (except of motor vehicles and motorcycles), repair of personal and household goods	52
transportation and postal services		
	land transport, transport via pipeline	60
	water transport	61
	air transport	62
	supporting and auxiliary transport activities; activities of travel agencies	63
	post and courier activities	64.1
banks and insurances		
	financial intermediation	65-67
technical services		
	research and development	73
	architectural and engineering activities and related technical consultancy	74.2
	technical testing and analysis	74.3
other business-related services		
	real estate activities	70
	renting of machinery without operator and of personal and household goods	71
	legal, accounting, book keeping and auditing activities; tax consultancy; market research and public opinion pools; business and management consultancy; holdings	74.1
	advertising	74.4
	labour recruitment and provision of personnel	74.5
	investigation and security services	74.6
	industrial cleaning	74.7
	miscellaneous business activities n.e.c.	74.8
	sewage and refuse disposal, sanitation and similar activities	90

2 IT Outsourcing and Employment Growth at the Firm Level

2.1 Introduction

Outsourcing is commonly not associated with employment growth at all. In public opinion, rather the opposite is the case as people usually associate job cuts with outsourcing. However, as recent research has shown (e.g. Wang et al., 2008; Amiti and Wei, 2009; Han et al., 2010), outsourcing can also lead to substantial improvements in firm performance, which might result in competitive advantages for the outsourcing firms. A stronger market position might additionally boost demand for the product and services offered by those firms which eventually enables them to raise employment to satisfy this positive demand shift.

This chapter is concerned with the outsourcing of information technologies (IT) and its effect on (medium-term) subsequent firm-level employment growth. IT outsourcing is a special case of outsourcing and it can be seen as the practice of turning over all or at least parts of an organisation's IT functions to an outside vendor.[1] Recent representative results from a survey among German

[1] Basically, there are two distinctions to be made concerning an outsourcing relationship: the legal and the geographical dimension. While the first one differentiates between external providers (not legally related to the outsourcing company) and subsidiaries or affiliates, the second dimension refers to the geographical location of the service provider. Outsourcing to a provider abroad is usually referred to as offshoring. This chapter is focussing on the 'real' external provision of IT services. Concerning the location of the vendor, there is no differentiation made between outsourcing and offshoring relationships, because the majority of firms in the data source out IT only locally. This can also be verified by other survey results (for Germany, see for example the ICT in enterprises survey 2007, conducted by the German Statistical Office).

manufacturing and service firms show that more than 78 percent of firms with five or more employees are engaged in IT outsourcing. In doing so, the shares in both sectors are almost equal. Especially firms in the service sector recently caught up, where the share of firms engaged in outsourcing increased by 15 percentage points compared to 2006 (ZEW, 2010).

Outsourcing has long been seen as a method to save costs, especially regarding IT outsourcing, where firms' poorly organised IT infrastructure led to a proliferation of costs. By outsourcing these services, firms expect to cut those costs significantly, and as a side effect, improve the quality of their IT services too. However, the motivation to outsource has changed during the last couple of years. Nowadays, firms act more strategically by also considering additional aspects rather than purely short term cost advantages. At the centre of this discussion lie the core competencies of the firm (Gottschalk and Solli-Saether, 2005). Firms should outsource their IT services to save resources and free management capacity, which in turn can be employed to concentrate on the strategic development of the firm. In the end, this can lead to a higher market share, and consequently, to more output. To satisfy the additional demand, an increase in employment is expected. Furthermore, IT outsourcing is a means to obtain access to the state-of-the-art technological advances in information technology. This helps to improve IT services and leads to more productive processes inside the firm (Ohnemus, 2007). Nevertheless, there are also risks associated with (IT) outsourcing, mainly regarding the relationship management (transaction costs) between the client and the vendor firm. An unprofessional relationship management can more than outweigh the advantages that are associated with IT outsourcing. The aim of this chapter is therefore to investigate the impact of IT outsourcing on employment growth empirically.

The study is based on the ZEW ICT surveys conducted in 2004 and 2007 in the German manufacturing and selected service industries. A total of more than 1 100 observations is available for the empirical analysis. Firm growth refers to the period from 2003 to 2006 and is based upon the (firm-level) employment figures measured for both time periods. IT outsourcing describes whether the firm outsourced at least one of the following three basic IT services to an external service provider: installation of hard- and software, computer system maintenance, user assistance and support. Due to the fact that IT outsourcing firms might also be the ones that are, overall, more successful, perhaps due to unobservable firm characteristics, like managerial abilities, this study controls for endogeneity by employing a two stage instrumental variable approach. Two instruments could be identified as particularly helpful: the drawing upon consulting for the year 2000 bug problem and the change in standard wages between 2000 and 2003.

As a main result, I find evidence that IT outsourcing has a positive effect on firms' employment growth rate. Dividing the sample into manufacturing and service firms, a medium-term positive growth effect of IT outsourcing, however, can only be observed in the service sector.

The chapter is structured as follows: Section 2.2 illustrates the background discussion on IT outsourcing and the proximity of (IT) outsourcing and (process/organisational) innovation is developed. Further, empirical evidence is presented concerning innovation and outsourcing on the one hand and employment on the other hand. The analytical framework is laid out in Section 2.3. Section 2.4 depicts the data set. The empirical results are discussed in Section 2.5 and Section 2.6 concludes.

2.2 Background Discussion

Three strands of literature can be seen as relevant for the topic analysed. First, the literature on IT outsourcing which is extensive, but yet misses an analysis concerning the contribution of IT outsourcing to employment growth in contract granting firms. Secondly, the very extensive literature on employment growth at the firm level. Various determinants of growth have been analysed so far, with process innovation probably coming closest to the practice of outsourcing. Thirdly, there are some studies on the relationship between (general and not IT-specific) outsourcing and employment growth, which can give some insights for the research conducted in this chapter.

So far, outsourcing still lacks a consistent definition, but basically, IT outsourcing involves the contracting out of information technology services, like the installation of hard- and software, computer system maintenance, user assistance and support, etc., to an external service provider. In the outsourcing context, legal and regional aspects are important characteristics of any outsourcing agreement. Legally, mostly *real* outsourcing, i.e. to a partner not legally associated with the client firm, is assumed. Regionally, we can differentiate between outsourcing to providers in the home country and to those located abroad.[2] The regional aspect has gained importance during the last couple of years, when (IT) offshoring (e.g. to India, Philippines and Eastern Europe) became more and more available and attractive (at least for larger firms). One of the first definitions of IT outsourcing was given by Loh and Venkatraman (1992a, p. 9). They define IT outsourcing as *"the significant contribution by external vendors in the physical and/or human resources associated with the entire or specific components of the IT infrastructure in the user organisation."* This means that any hardware as well as human capital (for example specialised

[2] Note that outsourcing abroad is also known as offshoring.

IT employees) can be outsourced both partly or completely. In their definition, Loh and Venkatraman do not differentiate between local and foreign IT outsourcing which is also not at the centre of interest in this chapter, because of its minor importance for the German IT outsourcing market (see, for example, Chapter 1).

IT outsourcing experienced a boost after Eastman Kodak's landmark decision in July 1989 to hand over its entire data centre and microcomputer operations to an external consortium headed by IBM. This decision was widely seen as a major point of departure for the customary in-house mode of IT governance (Loh and Venkatraman, 1995). Due to the prominence of this case, IT outsourcing defused more rapidly as firms started to consider IT outsourcing as a viable strategic option (Loh and Venkatraman, 1992b). Information technology was no longer seen as absolutely strategic, and, therefore, not suitable for outsourcing. The mantra now was: *"If Kodak can do it, why can't every other organisation?"* (Dibbern et al., 2004, p. 8). In a fairly recent survey provided by Eurostat (2007), on average 44 percent of firms with at least 10 employees in the EU27 outsource (fully or partly) information and communication technology (ICT) functions which require ICT/IT specialists in 2006. Some Scandinavian countries even reach values of more than 70 percent. Germany is also well above the average, with 65 percent of firms involved in IT outsourcing.

Looking at the strategic intent behind the IT outsourcing decision of the firms, Lacity et al. (2009) give a comprehensive overview of research contributing to this topic (see also Table A2.1 in the appendix). By far, *cost reduction* was the most common motive identified in the literature. But to focus on *core capabilities/competencies*, and *access to expertise and skills* immediately follows in second and third place. Although cost reduction is still a topic discussed in the IT outsourcing literature today, a shift is observable in the perception of the motives for IT outsourcing. Strategic reasons gained increasing importance during the last years.[3,4]

Reasons for a positive impact of IT outsourcing on firm-level employment growth are for both considerations, cost or strategic outsourcing, conceivable. Reduced cost for IT services, achieved basically through economies of scale on the vendor side, leads to lower final product prices and, subsequently, to a higher demand for those products. To satisfy this higher demand, additional

[3] A representative survey among German firms (which is also the source of the data employed in the empirical part of this chapter) constitutes that 69 percent of the IT outsourcing firms in 2004 see one of the main objectives for outsourcing in concentrating on core competencies. The higher quality services follows in the second place (53 percent) and cost reduction was mentioned only by 39 percent of the firms (ZEW, 2005).

[4] One of the most cited contributions to strategic IT outsourcing (in comparison to a pure cost saving outsourcing decision) has been made by DiRomualdo and Gurbaxani (1998).

employees are necessary for the production of these products. From a strategic point of view, IT outsourcing helps to conserve managerial effort, which then can be concentrated on the core capabilities of the firm, which have greater strategic potential for future success. Nevertheless, firms can still retain vitally important, and therefore core IT services, in-house (Smith et al., 1998), while outsourcing a significant portion of their non-core (and for their business success not so important) IT infrastructure/services. A second point here concerns the quality of IT services and firms' potential lack of knowledge on how to run their IT efficiently in-house. Service providers, due to their specialisation and their endowment with specialised IT personnel and top-end IT hardware, are able to offer IT services of higher quality and provide them more efficiently. Such improvements can be seen as process innovations which, in the end, may have a positive effect on employment.

In the literature, firm level employment growth is an extensively covered topic, with numerous studies analysing employment growth from various perspectives. The comprehensive survey by Coad (2007) gives an overview of both empirical and theoretical aspects of this literature. Reviewing the previous literature more deeply, the relationship between innovation and employment seems to fit the undertaken analysis in this chapter best. According to the Oslo manual, *organisational innovations* also include outsourcing of activities to external partners. In detail, an organisational innovation is defined as *"the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations"* (OECD, 2005). Organisational innovations are intended to increase firm performance by reducing costs, improving labour productivity and gaining access to external knowledge. The distinction, however, between *process*[5] and *organisational* innovations is frequently difficult, since both types of innovations seem to be similar, particularly regarding the mechanism of how they affect firm performance.

Comparing the supposed firm level effects of organisational/process innovations and outsourcing, similarities can also be found. Process innovations tend to displace labour (for a given output), since they are likely to reduce the quantities of most factors (including labour) required (Harrison et al., 2008). This, although much simpler, is also the case with IT outsourcing. Since IT specialists, formerly providing those IT services in-house, are displaced by the employees of the service provider, the immediate employment effect of outsourcing is assumed to be negative. In a second step, unit costs are reduced, due to labour (and/or capital) productivity increases associated with process innovations. Demand is stimulated through reduced product prices and, as a

[5] A process innovation is defined as "the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software" (OECD, 2005).

consequence, output and employment rise (Harrison et al., 2008). For IT outsourcing, empirical evidence of productivity effects, especially with respect to employees working at a computerised workplace, are found by Ohnemus (2007). Through higher productivity and, additionally, through lower costs for the outsourced services, the unit costs of production are decreased. Depending on the competitive conditions of the firm, this cost reduction is likely to result in lower prices, which stimulate demand, and hence output and employment.

Previous empirical literature on the employment effects of process/organisational innovations finds varying results. Looking at the R&D intensity of the firm (as an indicator for innovation), Hall (1985) observes that employment growth is related positively and significantly to R&D intensity. Additionally to R&D intensity, Greenhalgh et al. (2001) observe also that the number of patent publications have a positive effect on employment growth. Brouwer et al. (1993) present positive empirical evidence relating to product innovation activities and employment growth (although the effect is economically small). However, R&D cooperation, as a form of process and/or organisational innovation, turns out to have no influence on employment growth. Further, concerning process innovations, Doms et al. (1998) observe that the use of advanced manufacturing technology (which is assumed to correspond to process innovation) has a positive effect on employment. Van Reenen (1997) reveals a positive effect on employment for product innovations but insignificant results for process innovations. For manufacturing industries, Smolny (1998) shows that process innovations increase output and employment. However, the transmission mechanism remains unclear, since there is no price decreasing effect of process innovations observable. In their comparable analysis of four European countries (France, Italy, the UK and Germany), Harrison et al. (2008) observe a positive effect of product innovations on employment growth, whereas process innovations appear to have a negative effect on employment. Since the empirical evidence from this strand of literature yields no clear insights into the direction of the overall effect on employment, it is difficult to derive a hypothesis on IT outsourcing and employment growth. After all, to identify the direction of the analysed relationship remains an empirical question.

Various other determinants of employment growth have been considered in the literature, the most prominent among them are firm size and age (Evans, 1987b; Variyam and Kraybill, 1992; Dunne and Hughes, 1994),[6] financial performance, productivity, ownership structure (Harhoff et al., 1998), unionisation (Leonard, 1992) and the existence of a works council (Jirjahn, 2009), to mention a few. The available data set allows to control for a number of these variables (see Section 2.3).

[6] The age and the size of the firm are of course interrelated. Sometimes both are taken to represent what is essentially the same phenomenon (Coad, 2007).

To the best of my knowledge, there is no research yet available analysing the relationship between IT outsourcing and employment growth at the firm level. However, some contributions are made relying on the broader defined service outsourcing and offshoring. Since service outsourcing generally covers a wide variety of different functions, including also non-knowledge-intensive services like caretaker activities or security services, the results achieved in those studies can only give a first hint on what one might expect when it comes to outsourcing of knowledge intensive IT services. Hijzen et al. (2007) are among the first to provide firm-level evidence for the impact of service offshoring on employment. They find no evidence that the imports of intermediate services are associated with job losses. Actually, firms that import services have faster employment growth than those that do not. This might be a result of the cost-saving or productivity effects of offshoring, which give rise to an increase in the scale of production. Chongvilaivan et al. (2008) reveal a positive impact of service outsourcing on relative wages and the demand for skilled workers. This can be explained by the idea that outsourcing allows firms to specialise in upstream production activities where usually a greater number of skilled workers is employed. Recent work by Moser et al. (2009), using German establishment data, finds that offshoring establishments have higher productivity, higher market share and higher employment —compared to their non-offshoring counterparts. Although they are not differentiating between material and service offshoring,[7] which would be better comparable to IT outsourcing, this result suggests a positive effect of (international) outsourcing on employment at the firm level.

2.3 Analytical Framework

The analytical framework considers, besides the impact of IT outsourcing on employment growth, various other control variables which were found to be important in the previous firm-level employment growth literature. The model to be estimated can be specified as:

$$g_i = \alpha + \beta\, ITout_i + \boldsymbol{X_i\gamma} + \epsilon_i, \tag{2.1}$$

where g_i is the annual growth rate of firm i's workforce as defined later in equation (2.2) and $ITout_i$ is the dummy variable indicating if firm i sources out basic IT services. The vector $\boldsymbol{X_i}$ contains all the other explanatory variables included in the employment growth regression (e.g. original firm size, qualifica-

[7] Offshoring is defined as the share of foreign to total inputs.

tion structure of the employees, firm age, future business prospects, workplace practices, exposure to competition, etc.).

Equation (2.1) can be estimated by ordinary least square (OLS). However, it might be expected that IT outsourcing is not truly exogenous and therefore, it is impossible to make causal claims based upon OLS estimates. There are various unobserved firm characteristics which make the observed relationship between outsourcing and employment growth endogenous. So, for example, firms with a better management operate more successfully in the market. Their output increases compared to their competitors. As a consequence, those firms also show a higher employment growth rate. At the same time, better managed firms are more prone to IT outsourcing, since the executives of those firms recognise the strategic advantage of IT outsourcing. In the case of endogeneity, OLS estimates would be biased and inconsistent. To account for this endogeneity problem, I apply a two stage least squares instrumental variable approach.

For implementing instrumental variable regressions, suitable instruments must be at hand for the researcher. I decided to choose two instruments, a dummy variable indicating if firm i was involved in *Y2K consulting* (see also Ohnemus, 2007) and the change in standard wages between 2000 and 2003. The *Y2K consulting* variable refers to the *Year 2000 problem* (also known as the *Y2K bug*, or the *millennium bug*). This was a computer-related problem which resulted from the practice of abbreviating a four-digit year to the last two digits. In computer programs, the practice of representing the year with *two* digits becomes problematic with logical error(s) arising upon "rollover" from x99 to x00. This has caused some date-related processing to operate incorrectly for dates and times on and after January 1, 2000. Without corrective action, it was suggested that long-working systems would break down when the "... 97, 98, 99, 00 ..." ascending numbering assumption suddenly became invalid.[8] As the awareness of this problem arose, companies and organisations around the world checked, fixed, and upgraded their computer systems. On the one hand, the incidence of the Y2K bug is exogenous to all firms (having computers implemented in their businesses). On the other hand, it is plausible to assume that firms, once relying on external support for a computer related problem, are more prone to outsource their computer services later on. As a second instrument, I choose the increase in standard wages between 2000 and 2003 as provided by the German Statistical Office.[9] Since increases of the pay roll are in favour of the outsourcing decision (since external provision is nevertheless assumed to be

[8] This paragraph draws mainly on the Wikipedia entry for the Y2K-problem, see `http://en.wikipedia.org/wiki/Year_2000_problem` (February 24, 2010).

[9] This two digit industry level date is published in *Fachserie 16, Reihe 4.3* of the German Statistical Office. For the two-digit industries, where no data was available, the average evaluation of standard wages in Germany between 2000 and 2003 was imputed.

cheaper, because of scale effects), I assume that wage bill increases, previous to the growth rate calculation period, have no impact on employment growth between 2003 and 2006.

Further establishment characteristics are important to explain employment growth. One of the most outstanding variables, and therefore at the centre of numerous studies, is firm size, measured by the number of employees. In this context, Gibrat's law of proportional growth, which states that the probability of a proportionate increase in firm size over an interval in time is the same for all firms, regardless of their size at the beginning of the interval. In short, the original size of the firm and its growth rate are independent. However, empirically, this *law* is not universally confirmed. A large and growing body of research is even finding evidence of a (slightly) negative relationship between growth rates and firm size, so, for example, Kumar (1985) and Dunne and Hughes (1994) for the United Kingdom, Hall (1985) and Evans (1987a,b) for U.S. firms, Almus and Nerlinger (2002) for Germany and Goddard et al. (2000) for Japan. Some researchers maintain that Gibrat's law holds only for firms above a certain size threshold. Hart and Oulton (1996) find for a large sample of UK firms that mean reversion, i.e. small firms grow faster than large firms, is observed in the overall sample, while a decomposition of the data according to size classes reveals no relationship between size and growth for large firms (see also Geroski and Gugler, 2004, for a similar result). Because several authors (Evans, 1987b; Dunne and Hughes, 1994; Harhoff et al., 1998) find a highly nonlinear inverse size-growth relationship, I account for this by including a second order polynomial in the logarithm of firm size measured by the number of employees in the estimation model.

Qualification plays a crucial role in the development and the success of a firm. The qualification of the workforce is captured by the share of employees holding a university degree (*share university*) and the share of employees with vocational education (*share vocational*). Technology, especially information and communication technology affinity is captured by the share of employees working at a computerised workplace (*share computer employees*). The employment effects from the use of new technologies can be twofold, from a theoretical point of view. If the technology is labour saving, a firm can produce the same output with fewer employees. The cost-reducing aspect of the new technology, on the other hand, results in a competitive advantage which can lead to a higher market share of the firms products and will increase subsequently output and employment. Blanchflower and Burgess (1998) show that the positive employment effect dominates.

Firm's exposure to competition is captured by the inclusion of three measures. The first variable states whether a firm is active on the export market. The second measure indicates whether the company belongs to a group of firms. Fi-

nally, the third variable is an indicator of whether a firm has a foreign subsidiary. All three variables are binary indicators, taking the value one if the mentioned aspect applies to the firm. The existence of a works council might play a significant role for employment growth. Indeed, Jirjahn (2009) finds a positive growth effect of works councils for German manufacturing firms. Therefore, a dummy variable for the existence of a works council is included into the model. Since the typical dual system of employee representation in Germany (unions and works councils) applies especially to the manufacturing sector (Addison et al., 2007), a positive effect of the existence of a works council is expected mainly for manufacturing firms. Some authors emphasise the importance of the age of a firm for subsequent employment growth. For example, Dunne and Hughes (1994) find a negative relationship between firm age and employment growth. I account for firm age by including two dummies, one for relatively young firms being of age 0-3 years in 2003 and one for middle aged firms, being of age 4 to 7 years in 2003. The reference category are all firms older than 7 years.

A last important group of control variables deals with the organisation of work within the firm. Innovative workplace practices, especially when the whole system of work organisation is changed, results in enhanced productivity (Ichniowski et al., 1996). Improved productivity in turn strengthens the competitive position of the firm and could therefore result in a positive effect on employment growth. Three measures for new organisational practices are available: *quality circle*, *self dependent teams*, and *units with own cost and profit responsibility*. Each aspect is accounted for by the inclusion of a dummy which takes the value one if the respective organisational structure exists in a firm.

Employment growth is certainly dependent upon the business situation and the business prospect of a firm. Therefore, I include a variable indicating the expected growth in turnover on a three point likert scale (reduction, unchanged and increasing) for the year 2004 compared to 2003. Additionally, a dummy for East Germany is included to account for regional (and institutional) differences between East and West German firms. Finally, 13 industry dummies are included in the overall regression model to control for industry specific effects.

Remember that the choice of the time span for which the firm growth rate is calculated (three years) is aimed at looking at the medium-term impact of IT outsourcing on firm-level employment. This makes sense, since for any shorter time span, a negative effect would almost certainly be expected. In the short run, the displacement of jobs directly resulting from outsourcing (specialised IT employees are particularly affected in this respect) might dominate the positive effects of outsourcing leading to more employment.

2.4 Data

The data used for the empirical analysis stems from the ZEW ICT survey, a computer assisted telephone survey conducted in German manufacturing and service firms. The data was collected in 2004 and 2007. In each year, around 4 400 firms were surveyed. Stratification was made by industry affiliation (14 sectors),[10] firm size (eight size classes according to the number of employees) and region (West or East Germany).[11] The ZEW ICT survey focuses particularly on the diffusion and use of information and communication technologies. Furthermore, there are a number of variables controlling for numerous firm characteristics. Since the ZEW ICT survey is constructed as a panel, I merge the 2004 and 2007 waves in order to calculate the employment growth rate. After combining the two survey waves and considering item-non response, 1 154 observations remain for the empirical analysis.[12]

In the ZEW ICT survey, employment is measured as the average yearly number of employees of the firm. For the survey conducted in 2004, the average employment in 2003 is available and for the 2007 survey, employment figures refer to 2006. The employment growth rate is defined as the annual rate of employment change over the three year period from 2003 to 2006. Denoting the employment level of firm i in 2003 by L_i^{2003} and the level in 2006 by L_i^{2006}, the growth rate of firm i is defined as:[13]

$$g_i = \left[\frac{\ln(L_i^{2006}) - \ln(L_i^{2003})}{3} \right]. \tag{2.2}$$

As Table 2.1 shows, employment grew in the observed period between 2003 and 2006 on average by 0.39 percent per annum. The mean growth rate in the manufacturing sector is higher and lower in the service sector compared to the overall value.

The 2004 wave of the ZEW ICT survey contains information about a broad range of IT services companies potentially need for running their business. Firms were asked if they have outsourced any of those activities partially or fully to

[10] For a detailed list of the included sectors, see Table A2.6.

[11] The underlying survey sample is drawn from the data base of the *Verband der Vereine Creditreform*, Germany's largest credit rating agency.

[12] Some of the observations have to be dropped due to implausible growth rates, either caused by a wrong entry concerning the number of employees by the interviewer or by different reference companies in the two survey waves.

[13] Alternatively, two differently defined growth rates are employed for robustness checks: the compound annual growth rate, defined as: $\tilde{g}_i = (L_i^{2006}/L_i^{2003})^{\frac{1}{3}} - 1$, and a growth rate used by Davis and Haltiwanger (1992) upon others which is defined as: $\tilde{\tilde{g}}_i = \left[(L_i^{2006} - L_i^{2003})/3\right] / \left[(L_i^{2006} + L_i^{2003})/2\right]$. The last one may reduce the impact of outliers, since changes in employment are divided by average employment.

Table 2.1: Descriptive statistics

	All firms		IT outsourcing		non-IT outsourcing		Dummy
	Mean	STD	Mean	STD	Mean	STD	variable
employment growth rate	0.0040	0.1150	0.0083	0.1213	0.0013	0.1106	no
employees (2003)	181.6568	622.2314	158.1278	783.0564	196.9171	490.5772	no
size: 5-9 employees	0.1872	0.3902	0.1960	0.3974	0.1814	0.3856	yes
size: 10-19 employees	0.1629	0.3694	0.1938	0.3957	0.1429	0.3502	yes
size: 20-49 employees	0.2166	0.4121	0.2709	0.4449	0.1814	0.3856	yes
size: 50-249 employees	0.2860	0.4521	0.2577	0.4379	0.3043	0.4604	yes
size: $>$ 249 employees	0.1473	0.3546	0.0815	0.2739	0.1900	0.3926	yes
IT outsourcing	0.3934	0.4887	–	–	–	–	yes
Y2K consulting	0.5260	0.4995	0.6564	0.4754	0.4414	0.4969	yes
index standard wages	9.9610	1.0085	9.9370	0.9682	9.9766	1.0342	no
share university	0.1900	0.2366	0.1540	0.2075	0.2134	0.2511	no
share vocational	0.5989	0.2627	0.6326	0.2516	0.5770	0.2676	no
share computer employees	0.4360	0.3268	0.3977	0.3188	0.4608	0.3298	no
quality circle	0.4021	0.4905	0.3678	0.4827	0.4243	0.4946	yes
units w/ cost/profit resp.	0.3094	0.4624	0.2731	0.4461	0.3329	0.4716	yes
self dependent team	0.5763	0.4944	0.5507	0.4980	0.5929	0.4917	yes
exporter	0.4896	0.5001	0.4295	0.4956	0.5286	0.4995	yes
group of firms	0.3284	0.4698	0.2996	0.4586	0.3471	0.4764	yes
foreign subsidiary	0.0858	0.2802	0.0507	0.2195	0.1086	0.3113	yes
works council	0.3362	0.4726	0.2533	0.4354	0.3900	0.4881	yes
age: 0-3 years	0.0451	0.2075	0.0308	0.1731	0.0543	0.2267	yes
age: 4-7 years	0.1490	0.3563	0.1520	0.3594	0.1471	0.3545	yes
age: $>$ 7 years	0.8059	0.3957	0.8172	0.3869	0.7986	0.4014	yes
expected turnover	1.1880	0.7498	1.1916	0.7344	1.1857	0.7601	no
East Germany	0.2435	0.4294	0.2709	0.4449	0.2257	0.4184	yes
consumer goods	0.0910	0.2877	0.0969	0.2962	0.0871	0.2822	yes
chemical industry	0.0546	0.2273	0.0617	0.2408	0.0500	0.2181	yes
other raw materials	0.0754	0.2641	0.0859	0.2805	0.0686	0.2529	yes
metal and machine const.	0.1101	0.3131	0.1013	0.3021	0.1157	0.3201	yes
electrical engineering	0.0641	0.2451	0.0330	0.1789	0.0843	0.2780	yes
precision instruments	0.1014	0.3020	0.0947	0.2931	0.1057	0.3077	yes
automobile	0.0572	0.2323	0.0595	0.2368	0.0557	0.2295	yes
wholesale trade	0.0546	0.2273	0.0683	0.2525	0.0457	0.2090	yes
retail trade	0.0806	0.2723	0.0991	0.2992	0.0686	0.2529	yes
transport and postal serv.	0.0737	0.2613	0.0815	0.2739	0.0686	0.2529	yes
banks and insurances	0.0693	0.2541	0.0639	0.2448	0.0729	0.2601	yes
technical services	0.0893	0.2852	0.0617	0.2408	0.1071	0.3095	yes
o. business-related serv.	0.0789	0.2696	0.0925	0.2901	0.0700	0.2553	yes
# of observations	1 154		454		700		

Note: All variables (if not indicated otherwise) refer to the years 2003 or 2004.
Source: ZEW ICT survey 2004, 2007 and own calculations.

an external service provider. The activities covered range from basic IT services, like *hard- and software installation*, *computer system maintenance* and *user assistance and support*, to more sophisticated services, such as *software programming* and *IT security*. The empirical analysis is restricted to the outsourcing of basic IT services which includes the first three items mentioned above. The reason for that is that those services are required in every firm using computer technology in their business operations. More sophisticated IT services might not be needed by firms at all. Therefore, one would have a two-stage decision process. Firstly, the question whether a firm needs a specific service and secondly, the firm's make or buy decision. To avoid this problem, I focus on basic IT services only. IT outsourcing is defined by a binary variable which takes the value one if firm i outsources at least one of the three above mentioned IT services completely to an external service provider and zero otherwise.[14] Due to the fact that outsourcing is mainly realised at home, using German service providers as outsourcing partners, I exclude the *electronic processing and telecommunication* industry from the estimation sample, since this industry mainly comprises those firms providing IT outsourcing.

An overview of the sample structure by industry affiliation and the IT outsourcing intensity is given in Table 2.2. More than 55 percent of the firms in the sample belong to the manufacturing industries. Therein, *metal and machine construction* and *precision instruments* are the largest sub-industries. In the service sector, all sub-industries (besides *wholesale trade*) are almost equally distributed in the sample.

About 39 percent of the firms are involved in basic IT outsourcing. The *other raw materials industry* in the manufacturing sector is thereby most active with 45 percent of firms involved in IT outsourcing. On the other hand, the *electrical engineering* industry reaches only a value of 20 percent. In the service sector, the average outsourcing intensity is about 3 percentage points higher than in the manufacturing sector. Here, firms from the *wholesale trade* and *retail trade* are the most active outsourcers. Interestingly, the technologically advanced *technical services* industry is least active with an outsourcing share of only 27 percent. Figure 2.1 shows the relative frequencies of IT outsourcing in relation to firm size measured in number of employees. Since the outsourcing variable is binary, the relative frequencies are obtained by grouping the number of employees in size classes. The size of the individual dots reflects the number of firms in each group. After a slight increase in the outsourcing intensity in the three smallest size classes, the frequency drops sharply and continues to fall for the group of firms between 50 and 999 employees. For the larger firms with

[14] There is a strong correlation between the dummy variables (indicating complete outsourcing) of the three basic IT services, which suggests that a basic IT outsourcing indicator can be reliably constructed out of those three IT service variables.

Table 2.2: Share of observations by industry and IT outsourcing intensity

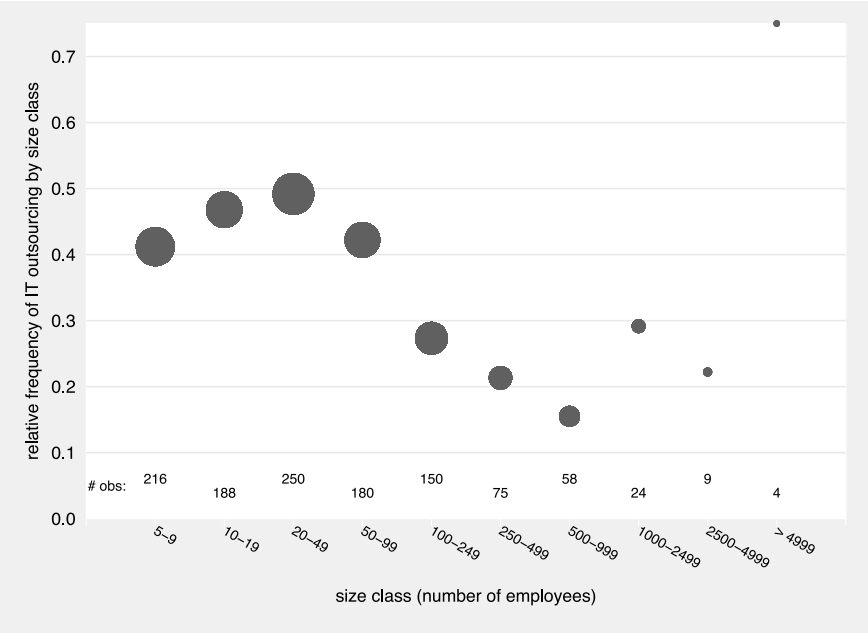
			thereof IT outsourcing	
Industry	**in % of obs.**	**# of obs.**	**in %**	**# of obs.**
Manufacturing:				
consumer goods	9.10	105	41.90	44
chemical industry	5.46	63	44.44	28
other raw materials	7.54	87	44.83	39
metal and machine construction	11.01	127	36.22	46
electrical engineering	6.41	74	20.27	15
precision instruments	10.14	117	36.75	43
automobile	5.72	66	40.91	27
Services:				
wholesale trade	5.46	63	49.21	31
retail trade	8.06	93	48.39	45
transport and postal services	7.37	85	43.53	37
banks and insurances	6.93	80	36.25	29
technical services	8.93	103	27.18	28
other business-related services	7.89	91	46.15	42
Total	100.00	1 154	39.34	454

Source: ZEW ICT survey 2004 and own calculations.

more than 999 employees, an increasing outsourcing tendency is observable, although this is based on a relatively small number of observations as indicated by the size of the dots.

All other establishment characteristics which are used to explain employment growth between 2003 and 2006 are listed in Table 2.1. All those variables refer to the year 2003 (and sometimes 2004). The average firm in the sample employs 182 employees in 2003. There are relatively more small firms with less than 50 employees in the service sector than in manufacturing. Overall, the mean value of the university share is 19 percent and the vocational share is almost 60 percent. While the university share is substantially lower in the manufacturing sector, the vocational share is almost identical in the manufacturing and the service sector. The average share of computer users is 44 percent and substantially higher in the service sector. In approximately 34 percent of all firms in the sample, a works council is installed. They are more prevalent in manufacturing industries, with 42 percent of firms having this kind of employee

Figure 2.1: IT outsourcing and firm size



Note: Size classes (in number of employees) versus the relative frequencies of IT outsourcing. The size of the dots indicates the number of firms in the considered interval.
Source: ZEW ICT survey 2004 and own calculations.

representation, than in the service sector (24 percent).[15] In the sample, the vast majority of firms (81 percent) is older than 7 years. This result is relatively stable in both sectors.

2.5 Empirical Results

Based on equation (2.1), three different specifications are estimated. While the first specification excludes variables describing the qualification structure of the employees and the information about the share of employees working predominantly at a computerised workplace, the following two specification successively include these variables. Estimation results are presented in Table 2.3. The first column for each specification shows the first stage results, the second column then presents the final estimates.

As we can see in the first line of Table 2.3, in all three specifications the coefficient of IT outsourcing is positive and significantly different from zero, implying a positive effect on the employment growth rate. Also, the magnitude of the co-

[15] The difference in the diffusion of works councils might partly result from the differences in firm size in both groups. Since the firms in the manufacturing subsample are larger, the probability for the existence of a works council is higher in this sector.

efficients for IT outsourcing is quite stable over all three specifications. While in the first case (without the qualification and computerisation employment share variables included), the mean effect in changing from non-IT outsourcing to IT outsourcing results in a 6.4 percent higher employment growth rate, the effect is only slightly smaller in the specification with qualification and computerisation variables included. This result supports the hypothesis that IT outsourcing improves firm performance (and maybe lowers producer prices), which results in the medium-term firm-level employment growth.

Turning to the interpretation of the control variables, the negative and significant coefficient of log labour is noticeable. The negative effect, although decreasing (as indicated by the positive sign of the squared log labour variable), rejects the validity of Gibrat's law of proportional growth in this data set. It rather states that small firms show a higher employment growth rate than large firms. Including labour force quality measures (share of employees with vocational training or university degree, respectively) does not significantly change the main result, as already mentioned. Furthermore, those variables do not exert any significant effect on the employment growth rate. The same holds true for the share of employees working at a computerised workplace, which is also an indicator for the IT intensity of the firm. Workplace practices, like the existence of a quality circle and units with cost and profit responsibility have the expected positive effect on employment growth, though, the coefficient for units with cost/profit responsibility is not significant in the second and third specification. Self dependent teams have a weakly significant negative effect on employment growth in the extensive third specification. This is somehow contrary to the expected result, since the existence of self dependent teams, which implies decentralised management practices, was also expected to have a positive impact on employment. The fact that a firm exports its products or services leads to an increased employment growth rate. This is interesting since a negative effect could also be expected because of higher competitive pressure which results in higher productivity (and less employment). But the additional demand from abroad seems to overcompensate this negative effect. Opposed to earlier research findings, the age of the firm has no significant impact on growth in this analysis. However, the age effect might already be captured by the employment size measure (log labour). The last coefficient which turns out to have a significant and positive sign is firms' perception about future growth in turnover.

It might be assumed that the outsourcing of services has different effects in manufacturing and service industries, since the service sector relies more heavily on service inputs compared to the manufacturing sector. Therefore, I split up the available sample into manufacturing and service firms and ran additional regressions to the ones presented in Table 2.3. Results are shown in

Table 2.3: IV estimation results for all firms

	Spec. 1		Spec. 2		Spec. 3	
	first	**second**	**first**	**second**	**first**	**second**
IT outsourcing		0.0640**		0.0625**		0.0622**
		(0.0297)		(0.0295)		(0.0294)
Y2K consulting	0.2298***		0.2303***		0.2308***	
	(0.0289)		(0.0288)		(0.0288)	
index standard wages	0.0678***		0.0657**		0.0660**	
	(0.0260)		(0.0260)		(0.0260)	
log labour	-0.0005	-0.0450***	-0.0082	-0.0427***	-0.0115	-0.0422***
	(0.0433)	(0.0101)	(0.0426)	(0.0101)	(0.0430)	(0.0101)
log labour squared	-0.0053	0.0044***	-0.0047	0.0042***	-0.0045	0.0042***
	(0.0052)	(0.0010)	(0.0051)	(0.0010)	(0.0052)	(0.0010)
share university			-0.2131**	0.0301	-0.1465	0.0201
			(0.0858)	(0.0239)	(0.0925)	(0.0256)
share vocational			0.0134	0.0282	0.0322	0.0254
			(0.0696)	(0.0194)	(0.0702)	(0.0194)
share computer employees					-0.1033*	0.0153
					(0.0563)	(0.0141)
quality circle	0.0153	0.0143**	0.0147	0.0141**	0.0150	0.0141**
	(0.0309)	(0.0071)	(0.0307)	(0.0071)	(0.0307)	(0.0071)
units w/ cost/profit resp.	-0.0079	0.0146*	-0.0021	0.0132	0.0011	0.0128
	(0.0339)	(0.0085)	(0.0341)	(0.0085)	(0.0340)	(0.0085)
self dependent team	-0.0244	-0.0114	-0.0228	-0.0115	-0.0171	-0.0124*
	(0.0294)	(0.0071)	(0.0293)	(0.0071)	(0.0294)	(0.0072)
exporter	-0.0559	0.0173*	-0.0430	0.0170*	-0.0365	0.0160*
	(0.0353)	(0.0091)	(0.0354)	(0.0089)	(0.0355)	(0.0089)
group of firms	0.0116	0.0072	0.0074	0.0066	0.0084	0.0065
	(0.0357)	(0.0100)	(0.0358)	(0.0101)	(0.0358)	(0.0101)
foreign subsidiary	-0.0452	-0.0122	-0.0264	-0.0124	-0.0275	-0.0122
	(0.0587)	(0.0148)	(0.0590)	(0.0144)	(0.0587)	(0.0143)
works council	-0.0739*	0.0050	-0.0722*	0.0041	-0.0706*	0.0038
	(0.0408)	(0.0079)	(0.0408)	(0.0078)	(0.0406)	(0.0077)
age: 0-3 years	-0.1280**	0.0114	-0.1368**	0.0106	-0.1376**	0.0107
	(0.0645)	(0.0152)	(0.0641)	(0.0153)	(0.0652)	(0.0153)
age: 4-7 years	0.0236	-0.0068	0.0256	-0.0068	0.0274	-0.0070
	(0.0396)	(0.0125)	(0.0395)	(0.0125)	(0.0394)	(0.0125)
expected turnover	0.0230	0.0176***	0.0254	0.0178***	0.0273	0.0176***
	(0.0186)	(0.0050)	(0.0187)	(0.0049)	(0.0187)	(0.0049)
East Germany	0.0372	0.0042	0.0486	0.0015	0.0415	0.0025
	(0.0337)	(0.0084)	(0.0343)	(0.0084)	(0.0344)	(0.0084)
constant	-0.3154	0.0545**	-0.2711	0.0286	-0.2629	0.0271
	(0.2869)	(0.0259)	(0.2940)	(0.0324)	(0.2930)	(0.0327)
industry dummies	yes	yes	yes	yes	yes	yes
R^2	0.1176		0.1251		0.1277	
Sargan-test		0.1924		0.1799		0.1792
# of observations	1 154	1 154	1 154	1 154	1 154	1 154

Note: Dependent variable: employment growth rate (2003-2006). *,** and *** indicate significance at the 10%, 5% and 1% level respectively. Robust standard errors are reported in parentheses. 13 industry dummies are included in the regressions. For the Sargan-test, *p*-values are reported.
Source: ZEW ICT survey 2004, 2007 and own calculations.

Tables A2.4 and A2.5 (in the appendix). The interpretation of the results is straightforward and I will first concentrate on the results for the manufacturing firms, as presented in Table A2.4.

Most strikingly, the coefficient for IT outsourcing turns out to be insignificant now, although the effect is still positive in all three specifications. Compared to the magnitude of the result for all firms, the IT outsourcing coefficient shows only half the size for the firms in the manufacturing industries. Since general IT applications in manufacturing do not play such a dominant role, positive business effects from outsourcing might be comparatively small. On the other hand, specialised IT applications in the production process, which might have a greater effect on business performance, are not outsourced, since they belong to the core competency of the firms. Concerning the rest of the estimates, Gibrat's law is again rejected by the negative and significant coefficient of the size parameter measured in log employees. Interestingly, the qualification of the employees and all three workplace practices included do not affect employment growth significantly. The only coefficient which shows an increase in size (and also in the level of significance) is the exporting indicator. This is unsurprising though, since especially German manufacturing firms rely heavily on the demand from abroad. An expected increase in future turnover is also positive and significant and the effect is slightly larger than in the overall sample.

The estimation result for the service firms are presented in Table A2.5. IT outsourcing has a positive and significant impact on employment growth in the service sector. Employment growth is in the range of 10.5 percent higher for IT outsourcing firms compared to their non-outsourcing counterparts. Again, Gibrat's law is rejected by the negative and significant log labour coefficients. Work organisation in the service sector seems to play an influential role for employment growth, although in different directions, as shown by the positive and significant coefficient for quality circles and the negative and significant coefficients for self dependent teams. Regarding the insignificant impact of those workplace organisation variables in the manufacturing subsample, the overall result seems to be driven by the service sector effects. The exporting indicator, however, is not significantly different from zero anymore. The same is true for expected future turnover.

The issue of model validation for discussion remains, especially the validity of the chosen instruments. In all specifications, the Sargan-test is rejected and hence, there is no indication of overidentification in any of the specifications. Altogether, the outsourcing of basic IT services to external providers has a significant impact on subsequent medium-term firm-level employment growth. However, when splitting up the sample into manufacturing and service firms, this effect is only significant in the service sector.

Table 2.4: IV estimation for different employment growth rate calculations

	All firms	**Manufacturing**	**Service**
Dep. Var.: g_i			
IT outsourcing	0.0622**	0.0342	0.1046**
	(0.0294)	(0.0312)	(0.0515)
Sargan-test	0.1792	0.1457	0.1954
Dep. Var.: $\tilde{g}_i$			
IT outsourcing	0.0508*	0.0310	0.0825*
	(0.0261)	(0.0300)	(0.0440)
Sargan-test	0.1587	0.1494	0.1607
Dep. Var.: $\tilde{\tilde{g}}_i$			
IT outsourcing	0.0599**	0.0348	0.0978*
	(0.0300)	(0.0325)	(0.0517)
Sargan-test	0.1850	0.1260	0.2331
# of observations	1 154	639	515

Note: *,** and *** indicate significance at the 10%, 5% and 1% level respectively. Robust standard errors are reported in parentheses. Estimations were carried out according to specification 3 in Tables 2.3, A2.4 and A2.5, respectively. The alternative growth rates are calculated as $\tilde{g}_i = (L_i^{2006}/L_i^{2003})^{1/3} - 1$ and $\tilde{\tilde{g}}_i = \left[(L_i^{2006} - L_i^{2003})/3\right] / \left[(L_i^{2006} + L_i^{2003})/2\right]$, where L_i^t refers to the number of employees of firm i at time t. For the Sargan-test, *p*-values are reported.
Source: ZEW ICT survey 2004, 2007 and own calculations.

To check the robustness of the results, I re-estimate the previous results by applying different methods for employment growth rate calculation.[16] Results of the IT outsourcing coefficient for different dependent variables (different growth rate calculations) and different samples (all firms, manufacturing firms and service firms) are shown in Table 2.4. The top part of the table lists the results already presented in Tables 2.3, A2.4 and A2.5 for reasons of comparability. The rest of the table then presents the estimated coefficients for IT outsourcing for the alternative growth rate calculations. As it can be easily observed, the size and the significance of the estimates only changes slightly compared to the original regressions. For the manufacturing sector, the effect on employment growth still remains positive but insignificant in both additional estimations. In

[16] See footnote 13 for alternative growth rate calculation methods.

the overall estimation and the one for the service firms only, the impact of IT outsourcing on employment growth seems to be somewhat smaller.

2.6 Concluding Remarks

The aim of this chapter is to analyse the effects of IT outsourcing on firm-level employment growth in the medium-term. Using an instrumental variable approach accounts for the possible endogeneity of IT outsourcing and the employment growth rate. German firm-level data from a comprehensive survey conducted in the years 2004 and 2007 is utilised.

Summarising the results, I find that IT outsourcing indeed influences the firm-level growth rate positively. Across the entire sample, the engagement in IT outsourcing raises the growth rate by more than 6 percent. By splitting the sample in manufacturing and service firms, further analysis reveals, however, that only the growth rate of firms in the service sector sector is significantly and positively affected by IT outsourcing. Indeed, manufacturing firms also show a positive coefficient, but this is not significant at any conventional significance level. The reason for the difference in both subsamples might be found in differing need for and extent of usage of information technology in both sectors. While IT is widely used in the service sector, it is less diffused in manufacturing. This can be verified by the share of employees working at a computerised workplace, which is on average 24 percentage points higher in the service sector. The minor importance of IT in manufacturing will also reduce the positive effects of IT outsourcing for the firms, and, as a consequence, its impact on employment growth.

There are some limitations underlying this research. First, firm exit is not observed in the available data. However, research in the past showed that firm exit plays a minor role, especially when short to medium time span growth rates are analysed (Hall, 1985). Additionally, firm exit is relevant, especially when very small firms are in the data, since their probability of leaving the market is considerably higher. The ZEW ICT survey is observing only firms with five and more employees and therefore skips those firms. Hence, I assume that firm exit did not influence the results significantly. Secondly, the observed time span of the growth rate is, as repeatedly mentioned, only three years. While a shorter time span would almost certainly lead to a negative impact of IT outsourcing because specialised IT employees are displaced (or transferred to the outsourcing

service provider)[17] and this reduction is hardly to be compensated by the positive effects of outsourcing, the long run impact is not clear yet. If firms tend to outsource IT services to achieve short to medium run advantages, the negative effects of outsourcing, namely loosing too much control and scope over the own processes, can, in the long run, affect outsourcing firms' employment growth rate negatively. Unfortunately, data to test this empirically is not available yet. And finally, the scope of this investigation was to analyse IT outsourcing. A differentiation between outsourcing and offshoring could not be made because of data restrictions. This aspect therefore has to be left for future research.

[17] Indeed, the share and the absolute number of employees in the IT service sector grew significantly between 1995 to 2007. While in 1995, 0.66 percent of all employees in Germany were employed in the IT service sector, which corresponds to approximately 250 000 employees, this share rose constantly to 1.42 percent until 2007, which corresponds to to a total number of approximately 564 000 employees (see Figure A2.1).

2.7 Appendix

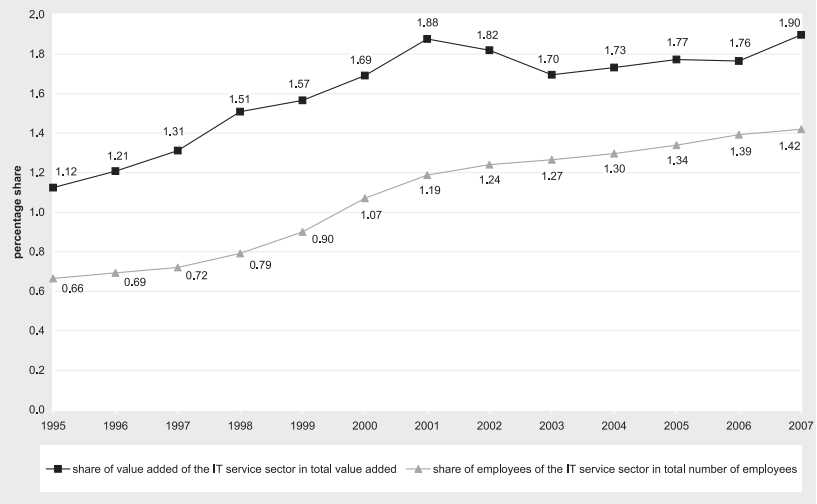
2.7.1 Tables and Figures

Table A2.1: Motivations for IT outsourcing

Motivation for IT outsourcing	Description	Number of articles
Cost reduction	A client organisation's need or desire to use outsourcing to reduce or control IS costs	39
Focus on core capabilities	A client organisation's desire or need to outsource in order to focus on its core capabilities	24
Access to expertise/skills	A client organisation's desire or need to access supplier(s) skills/expertise	18
Improve business/process	A client organisation's desire or need to engage a supplier to help performance improve a client's business, processes, or capabilities	17
Technical reasons	A client organisation's desire or need to gain access to leading edge technology through outsourcing	10
Flexibility	The ability to adapt to change	7
Political reasons	A client stakeholder's desire or need to use an outsourcing decision to promote personal agendas such as eliminating a burdensome function, enhancing their career, or maximising personal financial benefits	5
Change catalyst	A client organisation's desire or need to use outsourcing to bring about large scale changes in the organisation	4
Commercial exploitation	A client organisation's desire or need to partner with a supplier to commercially exploit existing client assets or form a new enterprise	3
Scalability	A client organisation's desire or need to outsource to be able to scale the volume of IS services based on demand	3
Access to global markets	A client organisation's desire or need to gain access to global markets by outsourcing to suppliers in those markets	2
Alignment of IS and business	The fit or congruence between a firm's business strategy (conceptualised as defenders, prospectors, analysers) and its outsourcing strategy (e.g., arm's length, independent, and embedded)	2
Cost predictability	A client organisation's desire or need to use outsourcing to better predict IS costs	2
Headcount reduction	A client organisation's need or desire to use outsourcing to reduce the number of staff	2
Need to generate cash	A client organisation's desire or need to generate cash through the sale of IT assets to the supplier	2
Rapid delivery	A client organisation's desire or need to engage in outsourcing in order to speedup project delivery	2
Innovation	A client organisation's desire or need to use outsourcing as an engine for innovation	1
Total articles		*143*

Source: Lacity et al. (2009, p. 134).

Figure A2.1: Share of employees (value added) from the IT service sector in total employees (value added) (Germany, 1995-2007)



Note: The IT service sector includes all firms belonging to NACE 72 (computer and related activities).
Source: The share of value added is base on input-output tables and the share of employees is based on Table 81000-0111, both provided by the Germany Statistical Office, and authors' calculations.

Table A2.2: Descriptive statistics for manufacturing firms

	Manufacturing		IT outsourcing		non-IT outsourcing		Dummy
	Mean	STD	Mean	STD	Mean	STD	variable
employment growth rate	0.0048	0.0946	0.0053	0.1000	0.0045	0.0912	no
employees (2003)	193.4257	586.2686	197.6860	824.7872	190.8287	373.8096	no
size: 5-9 employees	0.1455	0.3529	0.1322	0.3394	0.1537	0.3611	yes
size: 10-19 employees	0.1346	0.3415	0.1488	0.3566	0.1259	0.3322	yes
size: 20-49 employees	0.1800	0.3845	0.2438	0.4303	0.1411	0.3485	yes
size: 50-249 employees	0.3787	0.4854	0.3678	0.4832	0.3854	0.4873	yes
size: $>$ 249 employees	0.1612	0.3680	0.1074	0.3103	0.1940	0.3959	yes
IT outsourcing	0.3787	0.4854	–	–	–	–	yes
Y2K consulting	0.5336	0.4993	0.6612	0.4743	0.4559	0.4987	yes
index standard wages	10.3397	0.8002	10.3264	0.7524	10.3479	0.8289	no
share university	0.1450	0.1808	0.1162	0.1523	0.1625	0.1943	no
share vocational	0.6034	0.2415	0.6248	0.2329	0.5904	0.2459	no
share computer employees	0.3311	0.2539	0.2755	0.2299	0.3650	0.2619	no
quality circle	0.4773	0.4999	0.4380	0.4972	0.5013	0.5006	yes
units w/ cost/profit resp.	0.2942	0.4560	0.2438	0.4303	0.3249	0.4689	yes
self dependent team	0.5728	0.4951	0.5455	0.4990	0.5894	0.4926	yes
exporter	0.7152	0.4517	0.6405	0.4808	0.7607	0.4272	yes
group of firms	0.2864	0.4524	0.2893	0.4544	0.2846	0.4518	yes
foreign subsidiary	0.1111	0.3145	0.0702	0.2561	0.1360	0.3432	yes
works council	0.4178	0.4936	0.3554	0.4796	0.4559	0.4987	yes
age: 0-3 years	0.0485	0.2150	0.0372	0.1896	0.0554	0.2291	yes
age: 4-7 years	0.1534	0.3606	0.1777	0.3830	0.1385	0.3459	yes
age: $>$ 7 years	0.7981	0.4017	0.7851	0.4116	0.8060	0.3959	yes
expected turnover	1.2629	0.7634	1.2769	0.7579	1.2544	0.7676	no
East Germany	0.2347	0.4242	0.2727	0.4463	0.2116	0.4089	yes
consumer goods	0.1643	0.3709	0.1818	0.3865	0.1537	0.3611	yes
chemical industry	0.0986	0.2983	0.1157	0.3205	0.0882	0.2839	yes
other raw materials	0.1362	0.3432	0.1612	0.3684	0.1209	0.3264	yes
metal and machine const.	0.1987	0.3994	0.1901	0.3932	0.2040	0.4035	yes
electrical engineering	0.1158	0.3202	0.0620	0.2416	0.1486	0.3562	yes
precision instruments	0.1831	0.3871	0.1777	0.3830	0.1864	0.3899	yes
automobile	0.1033	0.3046	0.1116	0.3155	0.0982	0.2980	yes
# of observations	639		242		397		

Note: All variables (if not indicated otherwise) refer to the years 2003 or 2004.
Source: ZEW ICT survey 2004, 2007 and own calculations.

Table A2.3: Descriptive statistics for service firms

	Service		IT outsourcing		non-IT outsourcing		Dummy
	Mean	**STD**	**Mean**	**STD**	**Mean**	**STD**	**variable**
employment growth rate	0.0030	0.1362	0.0117	0.1420	-0.0030	0.1318	no
employees (2003)	167.0544	664.4435	112.9717	731.8495	204.8944	611.3091	no
size: 5-9 employees	0.2388	0.4268	0.2689	0.4444	0.2178	0.4134	yes
size: 10-19 employees	0.1981	0.3989	0.2453	0.4313	0.1650	0.3718	yes
size: 20-49 employees	0.2621	0.4402	0.3019	0.4602	0.2343	0.4243	yes
size: 50-249 employees	0.1709	0.3768	0.1321	0.3394	0.1980	0.3992	yes
size: $>$ 249 employees	0.1301	0.3367	0.0519	0.2223	0.1848	0.3888	yes
IT outsourcing	0.4117	0.4926	–	–	–	–	yes
Y2K consulting	0.5165	0.5002	0.6509	0.4778	0.4224	0.4948	yes
index standard wages	9.4911	1.0426	9.4925	0.9966	9.4901	1.0752	no
share university	0.2459	0.2817	0.1970	0.2499	0.2801	0.2976	no
share vocational	0.5932	0.2870	0.6414	0.2716	0.5594	0.2930	no
share computer employees	0.5661	0.3591	0.5372	0.3480	0.5864	0.3658	no
quality circle	0.3087	0.4624	0.2877	0.4538	0.3234	0.4686	yes
units w/ cost/profit resp.	0.3282	0.4700	0.3066	0.4622	0.3432	0.4756	yes
self dependent team	0.5806	0.4939	0.5566	0.4980	0.5974	0.4912	yes
exporter	0.2097	0.4075	0.1887	0.3922	0.2244	0.4179	yes
group of firms	0.3806	0.4860	0.3113	0.4641	0.4290	0.4958	yes
foreign subsidiary	0.0544	0.2270	0.0283	0.1662	0.0726	0.2599	yes
works council	0.2350	0.4244	0.1368	0.3444	0.3036	0.4606	yes
age: 0-3 years	0.0408	0.1980	0.0236	0.1521	0.0528	0.2240	yes
age: 4-7 years	0.1437	0.3511	0.1226	0.3288	0.1584	0.3657	yes
age: $>$ 7 years	0.8155	0.3882	0.8538	0.3542	0.7888	0.4089	yes
expected turnover	1.0951	0.7225	1.0943	0.6957	1.0957	0.7419	no
East Germany	0.2544	0.4359	0.2689	0.4444	0.2442	0.4303	yes
wholesale trade	0.1223	0.3280	0.1462	0.3542	0.1056	0.3078	yes
retail trade	0.1806	0.3850	0.2123	0.4099	0.1584	0.3657	yes
transport and postal serv.	0.1650	0.3716	0.1745	0.3805	0.1584	0.3657	yes
banks and insurances	0.1553	0.3626	0.1368	0.3444	0.1683	0.3748	yes
technical services	0.2000	0.4004	0.1321	0.3394	0.2475	0.4323	yes
o. business-related serv.	0.1767	0.3818	0.1981	0.3995	0.1617	0.3688	yes
# of observations	515		212		303		

Note: All variables (if not indicated otherwise) refer to the years 2003 or 2004.
Source: ZEW ICT survey 2004, 2007 and own calculations.

Table A2.4: IV estimation results for manufacturing firms

	Spec. 1		Spec. 2		Spec. 3	
	first	**second**	**first**	**second**	**first**	**second**
IT outsourcing		0.0347		0.0353		0.0342
		(0.0311)		(0.0314)		(0.0312)
Y2K consulting	0.2120***		0.2104***		0.2118***	
	(0.0401)		(0.0401)		(0.0396)	
index standard wages	0.0629**		0.0612*		0.0573*	
	(0.0316)		(0.0316)		(0.0314)	
log labour	0.0519	-0.0478***	0.0302	-0.0453***	0.0257	-0.0448***
	(0.0645)	(0.0137)	(0.0647)	(0.0139)	(0.0638)	(0.0139)
log labour squared	-0.0075	0.0043***	-0.0053	0.0041***	-0.0052	0.0040***
	(0.0080)	(0.0014)	(0.0080)	(0.0014)	(0.0079)	(0.0014)
share university			-0.2746**	0.0328	-0.1059	0.0181
			(0.1190)	(0.0290)	(0.1294)	(0.0332)
share vocational			-0.0479	0.0123	-0.0121	0.0091
			(0.0909)	(0.0183)	(0.0907)	(0.0186)
share computer employees					-0.2378***	0.0204
					(0.0795)	(0.0211)
quality circle	-0.0202	-0.0012	-0.0193	-0.0014	-0.0223	-0.0011
	(0.0403)	(0.0076)	(0.0402)	(0.0077)	(0.0399)	(0.0076)
units w/ cost/profit resp.	-0.0565	0.0002	-0.0418	-0.0016	-0.0330	-0.0024
	(0.0463)	(0.0090)	(0.0473)	(0.0090)	(0.0467)	(0.0089)
self dependent team	-0.0299	0.0050	-0.0339	0.0055	-0.0233	0.0046
	(0.0392)	(0.0079)	(0.0392)	(0.0079)	(0.0390)	(0.0078)
exporter	-0.1201**	0.0374***	-0.1032**	0.0360***	-0.0831*	0.0342***
	(0.0480)	(0.0104)	(0.0490)	(0.0104)	(0.0493)	(0.0101)
group of firms	0.0934*	0.0063	0.0931*	0.0059	0.0952*	0.0058
	(0.0524)	(0.0105)	(0.0526)	(0.0107)	(0.0525)	(0.0106)
foreign subsidiary	-0.1176	-0.0102	-0.1107	-0.0105	-0.1210	-0.0097
	(0.0787)	(0.0124)	(0.0791)	(0.0125)	(0.0787)	(0.0126)
works council	-0.0548	-0.0014	-0.0511	-0.0021	-0.0471	-0.0025
	(0.0528)	(0.0085)	(0.0528)	(0.0085)	(0.0523)	(0.0084)
age: 0-3 years	-0.0989	-0.0088	-0.0940	-0.0093	-0.0916	-0.0095
	(0.0878)	(0.0177)	(0.0861)	(0.0177)	(0.0879)	(0.0177)
age: 4-7 years	0.0952*	-0.0028	0.1024*	-0.0035	0.1029**	-0.0035
	(0.0528)	(0.0121)	(0.0529)	(0.0123)	(0.0523)	(0.0124)
expected turnover	0.0244	0.0280***	0.0295	0.0277***	0.0336	0.0273***
	(0.0246)	(0.0049)	(0.0250)	(0.0051)	(0.0249)	(0.0052)
East Germany	0.0479	0.0182*	0.0765	0.0145	0.0600	0.0159
	(0.0465)	(0.0095)	(0.0478)	(0.0100)	(0.0472)	(0.0100)
constant	-0.3760	0.0529*	-0.2724	0.0374	-0.2073	0.0358
	(0.3579)	(0.0300)	(0.3667)	(0.0362)	(0.3635)	(0.0366)
industry dummies	yes	yes	yes	yes	yes	yes
R^2	0.1139		0.1210		0.1320	
Sargan-test		0.1757		0.1697		0.1457
# of observations	639	639	639	639	639	639

Note: Dependent variable: employment growth rate (2003-2006). *,** and *** indicate significance at the 10%, 5% and 1% level respectively. Robust standard errors are reported in parentheses. Seven industry dummies are included in the regressions. For the Sargan-test, *p*-values are reported.
Source: ZEW ICT survey 2004, 2007 and own calculations.

Table A2.5: IV estimation results for service firms

	Spec. 1		Spec. 2		Spec. 3	
	first	**second**	**first**	**second**	**first**	**second**
IT outsourcing		0.1104**		0.1045**		0.1046**
		(0.0534)		(0.0516)		(0.0515)
Y2K consulting	0.2444***		0.2493***		0.2493***	
	(0.0430)		(0.0427)		(0.0427)	
index standard wages	0.0766		0.0739		0.0739	
	(0.0481)		(0.0476)		(0.0479)	
log labour	-0.0377	-0.0460***	-0.0360	-0.0418***	-0.0360	-0.0418***
	(0.0577)	(0.0153)	(0.0568)	(0.0150)	(0.0569)	(0.0151)
log labour squared	-0.0030	0.0047***	-0.0036	0.0044***	-0.0036	0.0044***
	(0.0069)	(0.0017)	(0.0068)	(0.0016)	(0.0068)	(0.0016)
share university			-0.1991	0.0530	-0.1997	0.0531
			(0.1304)	(0.0432)	(0.1339)	(0.0448)
share vocational			0.0596	0.0620	0.0593	0.0620
			(0.1113)	(0.0382)	(0.1122)	(0.0383)
share computer employees					0.0011	-0.0002
					(0.0771)	(0.0199)
quality circle	0.0422	0.0336**	0.0406	0.0343**	0.0406	0.0343**
	(0.0477)	(0.0135)	(0.0473)	(0.0133)	(0.0476)	(0.0133)
units w/ cost/profit resp.	0.0426	0.0254	0.0389	0.0245	0.0389	0.0245
	(0.0500)	(0.0166)	(0.0497)	(0.0164)	(0.0497)	(0.0164)
self dependent team	-0.0272	-0.0348**	-0.0176	-0.0367***	-0.0177	-0.0367**
	(0.0450)	(0.0137)	(0.0450)	(0.0141)	(0.0455)	(0.0143)
exporter	-0.0018	-0.0112	0.0065	-0.0123	0.0065	-0.0123
	(0.0518)	(0.0166)	(0.0517)	(0.0164)	(0.0517)	(0.0164)
group of firms	-0.0556	0.0130	-0.0600	0.0128	-0.0600	0.0128
	(0.0486)	(0.0168)	(0.0486)	(0.0166)	(0.0487)	(0.0166)
foreign subsidiary	-0.0460	0.0079	-0.0089	0.0090	-0.0090	0.0090
	(0.1017)	(0.0358)	(0.1030)	(0.0340)	(0.1035)	(0.0342)
works council	-0.1331**	0.0264	-0.1314**	0.0253	-0.1314**	0.0253
	(0.0653)	(0.0168)	(0.0648)	(0.0164)	(0.0649)	(0.0163)
age: 0-3 years	-0.2371**	0.0527*	-0.2675***	0.0477	-0.2675***	0.0477
	(0.0959)	(0.0301)	(0.0971)	(0.0308)	(0.0974)	(0.0308)
age: 4-7 years	-0.0752	-0.0061	-0.0780	-0.0059	-0.0780	-0.0059
	(0.0588)	(0.0234)	(0.0592)	(0.0234)	(0.0592)	(0.0234)
expected turnover	0.0128	0.0063	0.0078	0.0060	0.0078	0.0060
	(0.0288)	(0.0095)	(0.0288)	(0.0096)	(0.0289)	(0.0095)
East Germany	0.0321	-0.0090	0.0307	-0.0114	0.0308	-0.0115
	(0.0505)	(0.0150)	(0.0503)	(0.0147)	(0.0508)	(0.0147)
constant	-0.2143	0.0405	-0.1579	-0.0098	-0.1580	-0.0097
	(0.4758)	(0.0425)	(0.4832)	(0.0555)	(0.4837)	(0.0563)
industry dummies	yes	yes	yes	yes	yes	yes
R^2	0.1645		0.1759		0.1759	
Sargan-test		0.2168		0.1964		0.1954
# of observations	515	515	515	515	515	515

Note: Dependent variable: employment growth rate (2003-2006). *,** and *** indicate significance at the 10%, 5% and 1% level respectively. Robust standard errors are reported in parentheses. Six industry dummies are included in the regressions. For the Sargan-test, *p*-value are reported.
Source: ZEW ICT survey 2004, 2007 and own calculations.

Table A2.6: Industry classification

Industry	Explanation	NACE
consumer goods		
	manufacture of food products, beverages and tobacco	15-16
	manufacture of textiles and textile products	17-18
	manufacturing of leather and leather products	19
	manufacture of wood and wood products	20
	manufacturing of pulp, paper and paper products; publishing and printing	21-22
	manufacturing n.e.c.	36-37
chemical industry		
	manufacture of coke, refined petroleum products and nuclear fuel	23
	manufacture of chemicals, chemical products and man-made fibres	24
other raw materials		
	manufacture of rubber and plastic products	25
	manufacture of non-metallic mineral products	26
	manufacture of basic metal	27
metal and machine construction		
	manufacture of fabricated metal products (except machinery and equipment)	28
	manufacture of machinery and equipment n.e.c.	29
electrical engineering		
	manufacture of office machinery and computers	30
	manufacture of electrical machinery and apparatus n.e.c.	31
	manufacture of radio, television and communication equipment and apparatus	32
precision instruments		
	manufacture of medical, precision and optical instruments, watches and clocks	33
automobile		
	manufacturing of transport equipment	34-35
wholesale trade		
	wholesale trade and commission trade (except of motor vehicles and motorcycles)	51
retail trade		
	sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	50
	retail trade (except of motor vehicles and motorcycles), repair of personal and household goods	52
transportation and postal services		
	land transport, transport via pipeline	60
	water transport	61
	air transport	62
	supporting and auxiliary transport activities; activities of travel agencies	63
	post and courier activities	64.1
banks and insurances		
	financial intermediation	65-67
technical services		
	research and development	73
	architectural and engineering activities and related technical consultancy	74.2
	technical testing and analysis	74.3
other business-related services		
	real estate activities	70
	renting of machinery without operator and of personal and household goods	71
	legal, accounting, book keeping and auditing activities; tax consultancy; market research and public opinion pools; business and management consultancy; holdings	74.1
	advertising	74.4
	labour recruitment and provision of personnel	74.5
	investigation and security services	74.6
	industrial cleaning	74.7
	miscellaneous business activities n.e.c.	74.8
	sewage and refuse disposal, sanitation and similar activities	90

3 Productivity Effects of Business Process Outsourcing: A Firm-level Investigation Based on Panel Data

3.1 Introduction

Outsourcing has become more and more important for corporate strategy in recent years. Grossman and Helpman (2005, p. 135) even state that *"we live in an age of outsourcing"*. According to them, firms subcontract *"an ever expanding set of activities, ranging from product design to assembly, from research and development to marketing, distribution and after-sales services"*. The outsourcing of services like these can be subsumed under the term of business process outsourcing (BPO). BPO is a subset of (service) outsourcing that involves the contracting of the operations and responsibilities of specific business functions (or processes) to a third-party service provider.

However, although firms increasingly rely on BPO, research on the performance enhancing effects of BPO for the contract granting firm is still limited. Until now, research has to a large extent been restricted to the investigation of the determinants of BPO (Yang et al., 2007; Lacity et al., 2009). The aim of this chapter, therefore, is to provide empirical evidence on this topic, by analysing the productivity effects of BPO for the outsourcing firms, using German firm-level panel data.

The overall significance of services as an intermediate input into the production process of firms is undisputed. Thereby firms can basically choose between providing the required services themselves or subcontracting to external ser-

vice vendors.[1]. The growing importance of subcontracting business services in Germany is reflected in Figure A3.1 (in the appendix). It shows the share of inputs from the *corporate service* sector, which can be regarded as the BPO providing sector,[2] at the total production value in Germany between 1995 and 2007.[3] The share of those intermediate inputs rose from 6.07 percent in 1995 to 7.5 percent in 2007 which accumulates in a total increase of almost 24 percent over the twelve year period. Although, at a first glance, an increase of 1.43 percentage points seems rather moderate, the absolute values behind this figure are quite substantial. In 2007, for example, the absolute sum of intermediate inputs provided to other sectors of the economy amounts to 349 billion euros. Thereby imports play a minor role which is indicated by the distance between the straight and the dashed line in Figure A3.1. As can be easily verified, this share is only small but has, nevertheless, continuously risen during the last years.[4] The outsourcing behaviour is certainly different in manufacturing and service industries, since the absolute demand for intermediate services in manufacturing is lower. By conducting previous calculations separately for the manufacturing and service sector in Germany, it can be found that the increase in manufacturing for external business services is not as pronounced compared to the service industry. Whereas the demand in manufacturing rose by about 12 percent between 1995 and 2007, the service sector registered an increase of more than 26 percent. Consequently, the increase in business service outsourcing is predominantly driven by a boost in demand for such services in the service sector. Additionally, we can observe that in the service industries, the share of imports of business services is substantially higher (see Figures A3.2 and A3.3 in the appendix).

The boost in demand for corporate services has led to an expansion of this sector during the last decade. The share of value added in the corporate service sectors in Germany rose from 9 percent almost continuously to 12 percent as

[1] Especially very large firms or firms with several subsidiaries sometimes establish their own legally independent service division which then provides services to all other subsidiaries within the group. In some cases, those service divisions also offer their services to other (external) companies.

[2] The corporate service sector comprises firms belonging to the sectors *computer and related activities* (NACE 72), *research and development* (NACE 73) and *other business activities* (NACE 74). This is of course a very broad definition when one is interested in business process outsourcing. Eurostat, for example, includes only firms belonging to NACE 72 and NACE 74.1 to 74.5 when defining the so called *business service* sector. But because input-output tables are only available on a two digit level, I decided to choose a wider definition.

[3] 2007 is the most recent point in time for which input-output information is available from the German Statistical Office

[4] In 2007, the share of imports from the corporate service sector amounted to 30 billion euros or 8.7 percent of the total inputs from this sector.

displayed in Figure A3.4 (in the appendix). This amounts to an increase of almost 34 percent. Correspondingly, also the share of employees working in the corporate service sector grew significantly. In 1995, this sector accounted for 7.4 percent of total employment which increased by 72 percent to 12.7 percent until 2007. Altogether, as the demand for externally provided corporate services increased, simultaneously the corporate service sector itself expanded. Since only a minor fraction of business services is imported, as shown above, this growth is required to cover increased demand.

Although, as the just presented figures underline, business process and business service outsourcing became increasingly attractive to firms, still the question has to be asked why firms actually decide to resort to external providers at all. Usually, business process outsourcing is associated with a loss in decision power, at least in the short run, because the main process responsibility is transferred to the outsourcing vendor. Flexible short term reactions to a changing market environment are therefore not always possible and depend upon the cooperation of the service provider. A central argument in favour of service outsourcing is the desire of firms to focus more on their core activities. In a representative survey, more than 82 percent of the outsourcing firms mention this argument as the main driver for subcontracting business processes (ZEW, 2007).[5] To achieve this goal, firms source out all (or at least parts) of their non-core activities (Gilley and Rasheed, 2000; Merino and Rodríguez Rodríguez, 2007).

In what follows, a Cobb-Douglas production function is used as framework to analyse whether firms that are engaged in the outsourcing of business processes gain advantages in terms of productivity. A comprehensive panel survey conducted in the German manufacturing and service industries between 2000 and 2007 by the Centre for European Economic Research (ZEW) is employed. In order to account for unobserved firm heterogeneity, measurement errors in the variables and simultaneity of inputs and output, different estimation techniques are applied, among them Olley and Pakes' (1996) approach and a system-GMM estimation technique (Arellano and Bover, 1995; Blundell and Bond, 1998). The results (over all estimation procedures) clearly show a positive and significant impact of business process outsourcing on firm-level productivity. According to the preferred system-GMM estimation results, the engagement in BPO has a positive effect of approximately 9 percent.

The chapter is structured as follows: Section 3.2 gives a definition of business process outsourcing and develops the main hypothesis. Furthermore, an empirical literature review focussing on business process outsourcing and productivity research is presented. Section 3.3 introduces the estimation procedures. In

[5] Cost reduction and process optimisation only follow in second and third place with 59 percent and 51 percent, respectively.

Section 3.4, the data set and the applied transformation steps are presented. Section 3.5 discusses the estimation results and makes some robustness checks. Section 3.6 concludes.

3.2 Background Information

Business process outsourcing is a collective term referring to subcontracting arrangements in all fields of economic activity of the firm. While originally, BPO was associated with manufacturing firms' outsourcing of production processes, contemporaneously it is primarily used to refer to the outsourcing of services. According to the International Data Corporation (IDC), one of the leading market research and analysis enterprises specialising in information technology, *BPO involves the transfer of management and execution of one or more complete business processes or entire business functions to an external service provider. The BPO vendor is part of the decision-making structure surrounding the outsourced process or functional area, and performance metrics are primarily tied to customer service and strategic business value. Strategic business value is recognised through results such as increased productivity, new business opportunities, new revenue generation, cost reduction, business transformation, and/or the improvement of shareholders' value*. This definition leads to three main characteristics which distinguish BPO from other types of outsourcing. First, a certain amount of risk is transferred to the vendor which runs the process on behalf of the contract granting firm. An outsourcing provider does not only take over administrative responsibility for a technical function, but also assumes strategic responsibility for the execution of a complete, *business-critical* process. This additional step can introduce new efficiencies and cost savings for the outsourcing company, while it also enables the service provider to deliver important strategic benefits to the customer. Second, the business connection between firm and subcontractor is individual, so that the external provision of low-level services (e.g. janitorial, security or cleaning services) is usually not categorised as BPO. Last, the service provider is actively involved in the long term strategic and operational success of the outsourcing firm. BPO relationships are usually based on long term contracts with durations of around 5 to 10 years. This is primarily due to the fact, that initially, relationship specific investments by the service provider have to be undertaken.

Typically, BPO comprises services from the area of finance and accounting, human resource management, procurement, logistic, customer care, programming and IT-infrastructure. Since most services in the BPO context rely heavily on information and communication technologies, BPO is sometimes also cate-

gorised as information technology enabled services (Ramachandran and Voleti, 2004; Sharma et al., 2005).

An important feature of business process outsourcing is its ability to free corporate executives from some of their day-to-day process management responsibilities (DiRomualdo and Gurbaxani, 1998). Since firm executives usually spend a lot of time managing the everyday business and only little time on formulating strategies for a successful advancement of the company, BPO can help to reverse this ratio. Once a business process is successfully outsourced, more management capacity remains to focus on customer needs, upgrade the main business activities and explore new revenue areas. In other words, BPO helps firms to concentrate on their core competencies. Additionally, outsourced services are usually carried out by highly specialised and qualified vendor companies. The experts within those firms bring increased productivity and years of experience with them, that the vast majority of outsourcing firms previously did not have access to or could not afford on their own. This leads to better service quality and a faster adoption of well-defined business processes (Merino and Rodríguez Rodríguez, 2007). A last, important point in favour of BPO is the cost advantage associated to service outsourcing. As just mentioned, BPO vendors are highly specialised on the services they offer. Usually, parts of a outsourced business service are standard for a vast majority of the BPO providers' customers. This implies economies of scale on the vendor side and results in lower costs for the contract granting firm (compared to in-house provision) at least in the long run, when the cost for search and contracting and initial coordination costs are incorporated (Quinn and Hilmer, 1994). Altogether, it can be assumed that BPO will enable outsourcing firms to capture new efficiencies and consequently improve their productivity.

The literature with a specific BPO focus is still scarce, although in recent years, efforts have been made to cover this topic more thoroughly. Willcocks et al. (2004), for example, stress the knowledge potential inherent to (IT-intensive) business process outsourcing, which is the premise for the dramatic growth of BPO since 2001. Indeed, the data I use in this chapter also shows a high increase in BPO starting in the year 2000, as stated in Figure A3.6 (in the appendix). The analysis by Sen and Shiel (2006) goes even further by looking at the transformation from business process outsourcing to knowledge process outsourcing, a variation/specialisation of the first one mentioned. How to control business process outsourcing relationships is discussed in Daityari et al. (2008). They assume an increasing trend in BPO, especially to obtain information and expert knowledge. For a successful partnership between the BPO client and service firm, the arrangement of well defined control functions is essential, especially when the outsourcing partners are located in different regions of the world. Lesher and Nordås (2006) analyse the role of business services by a cross-

country comparison of selected OECD (and non-OECD) countries, referring to data provided by input-output tables. The results suggest that access to a wider variety of business services improves productivity in manufacturing. Additionally, economies profit from offshoring in business services because of lower costs and a greater variety offered. In their firm-level study of internal and external R&D provision (which is a special kind of business service) on labour productivity, Lokshin et al. (2008) find complementarity between internal and external R&D, with a positive impact of external R&D only evident in case of sufficient internal R&D. However, they can also show that productivity is increasing in the share of external R&D in total R&D. Although R&D outsourcing is somehow special, this result nevertheless highlights the importance of an appropriate information exchange between outsourcing and service providing firm. Hölzl et al. (2007) examine the short- and long run implications of outsourcing. They find that outsourcing of knowledge intensive business services has, in the short run, a positive effect on productivity. This, however, reverses in the long run, because the potential for organisational innovation is reduced by outsourcing which places them beyond the control of the firms' management.[6]

Given the proximity of BPO to information technology and service outsourcing in general, one can additionally draw on the extensive strand of literature dealing with these two aspects to gain further insights on the topic.

Various authors have analysed the determinants of IT outsourcing and offshoring, for instance Loh and Venkatraman (1992a) as well as Barthélemy and Geyer (2001; 2004; 2005). The research devoted to performance effects basically concentrates on (labour) productivity and profitability. Maliranta et al. (2008) thereby find that IT outsourcing enhances an organisation's IT use and thus boosts its labour productivity. In contrast, Bertschek and Müller (2006) cannot find any significant differences in key variables between outsourcing and non-IT outsourcing firms. They even find that firms without IT outsourcing produce more efficiently than those involved in IT outsourcing. Ohnemus (2007) in turn comes to the opposite conclusion: IT outsourcing firms are more efficient in their production processes compared to non-IT outsourcers. Furthermore, he finds that employees working at a computerised workplace are more productive when IT outsourcing is given.[7]

[6] There is also some literature analysing the developments in the (business) service sector. Here, the most important contributions were made by Fixler and Siegel (1999) and Sako (2006).

[7] For a comprehensive overview of the IT outsourcing literature, see, for example, Dibbern et al. (2004) and Lacity et al. (2009).

Regarding the determinants of service outsourcing, Abraham and Taylor (1996) constitute the beginning of this strand of empirical literature.[8] They find that service outsourcing is driven by the size of the firm, the cost reduction argument (through economies of scale by the vendor) and the susceptibility to demand fluctuation. However, these arguments are not universally valid for all services. Girma and Görg (2004) state the importance of the nationality of a firm's ownership for service outsourcing abroad, where foreign-owned firms are more inclined to outsourcing. Spatial agglomeration is introduced by Antonietti and Cainelli (2008). They find that location within a dense and technologically developed industrial district has a positive effect on service outsourcing, mainly due to the geographic proximity to service providers. A similar result was found by Ono (2003). The probability of outsourcing advertising, bookkeeping and accounting, and legal services is higher the greater the size of the local market for those services. This underlines that although the outsourcing of service can by now be easily undertaken over very long distances, due to the digitisation of business processes, outsourcing firms still prefer close (personal) contact to their service providers. The contribution of Merino and Rodríguez Rodríguez (2007) highlights the importance of looking at different outsourced services specifically, since coefficients of explanatory variables differ (in size, sign and significance) tremendously. Information and communication technology also plays a crucial role in explaining service outsourcing. A positive relationship between service outsourcing (in detail: communications, accounting and bookkeeping, and software services) and the IT intensity of firms is stated by Bartel et al. (2006). They argue that the cost of outsourcing is the price of the service plus an adjustment cost specific to the firm. The higher the IT content of the firm's production technology, the lower the adjustment costs and the more likely it is to outsource. The reason is that new information technologies are relatively intensive in their requirement of general skills, i.e. skills that can be easily transferred across firms and sectors. The IT content of both the services and the production technology at the using firms generates a technological compatibility between the firm's use of its own technology and its ability to use others' technologies. Abramovsky and Griffith (2006) focus on the capability of ICT to reduce adjustment costs of outsourcing. Consequently, ICT-intensive firms purchase more services on the market. Furthermore, transaction costs are also reduced by ICT which allows a greater geographical distance between the outsourcing firm and its service provider.

While most of the empirical literature which analyses the relationship between outsourcing (and especially offshoring) and firm performance is focussing

[8] Theoretical aspects concerning the determinants of outsourcing (and offshoring) can be found in Grossman and Helpman (2003, 2005) and Antràs et al. (2006).

on purchased materials,[9] the service outsourcing strand is still scant.[10] On the industry level, one of the earliest contribution was made by Siegel and Griliches (1992). They constitute that measured productivity increases in U.S. manufacturing cannot be attributed to increases in purchased services or foreign outsourcing for the late 1970s and early 1980s. In contrast, Ten Raa and Wolff (2001) state that outsourcing of services was partly responsible for the recovery in TFP growth in U.S. manufacturing during the 1980s. In their opinion, manufacturing industries have been successful at externalising the slow productivity growth service activities. Amiti and Wei (2005) look at service offshoring and find that although media and politics raise a lot of attention about this topic, mainly because of the associated job losses of highly qualified employees in industrialised countries, service offshoring in the U.S. and in most other countries is still very low. In a related paper, they analyse the effect of service and material offshoring on productivity in U.S. manufacturing between 1992 and 2000 and find positive effects on productivity (Amiti and Wei, 2009). While material offshoring accounts for 5 percent of labour productivity growth, service offshoring accounts for around 10 percent. Görg and Hanley (2004) analyse the relationship between outsourcing and profitability at the firm-level, using data for the electronics sector in Ireland. Large firms clearly benefit from material outsourcing (as opposed to smaller firms), but there are no clear cut results for service outsourcing. These results basically also apply when looking at international outsourcing (offshoring) and productivity (Görg and Hanley, 2005). Positive effects from offshoring of services on productivity in Irish manufacturing data are found by Görg et al. (2008), but only if the firm is operating on the export market. For non-exporting firms, no statistically significant impact of international outsourcing of services on productivity can be detected.

To summarise, the results of the existing empirical literature on the interdependence between outsourcing and productivity are very diverse. Especially evidence on the relationship between business process outsourcing and productivity is still missing. Therefore, the following analysis shall help to close this gap, by providing reliable empirical evidence of the productivity enhancing effects of BPO for German manufacturing and service firms.

[9] Some newer studies that do not specifically distinguish between material and service outsourcing/offshoring or focus completely on materials are presented by Tomiura (2005; 2007), Hijzen et al. (2010), Jabbour (2010), Broedner et al. (2009) and Wagner (2009).

[10] Heshmati (2003), Olsen (2006) and Jiang and Qureshi (2006) provide surveys on this topic.

3.3 Analytical Framework

As an analytical framework for investigating the impact of business process outsourcing on output at the firm-level, I refer to a Cobb-Douglas production function with capital and labour as inputs:

$$\begin{aligned} Y_{it} &= F(A_{it}, L_{it}, K_{it}, BPO_{it}) \\ &= A_{it} \;\; L_{it}^{\alpha} \;\; K_{it}^{\beta} \;\; \mathrm{e}^{\gamma BPO_{it}}, \end{aligned} \tag{3.1}$$

where Y_{it} denotes the output of firm i at time t, L_{it} and K_{it} represent labour and capital input, and A_{it} represents multi-factor productivity. BPO_{it} indicates whether firm i is outsourcing business processes in period t. The logarithm of multi-factor productivity $\log(A_{it})$ is decomposed into a common scale parameter c, a firm-specific (quasi) fixed part η_i, reflecting firm-specific characteristics that do not (considerably) vary in the short run, like firm strategy, organisational capital or management ability, a time-variant industry-specific part $\lambda_{j(i),t}$,[11] and a time-variant firm specific residual ϵ_{it}:

$$\ln(A_{it}) = c \;\; + \;\; \eta_i \;\; + \;\; \lambda_{j(i),t} \;\; + \;\; \epsilon_{it}. \tag{3.2}$$

After taking logarithms on both sides of equation (3.1) and inserting equation (3.2), the empirical model can be written in the following way:

$$y_{it} \;=\; c \;+\; \alpha \; l_{it} \;+\; \beta \; k_{it} \;+\; \gamma \; BPO_{it} \;+\; \eta_i \;+\; \lambda_{j(i),t} \;+\; \epsilon_{it}, \tag{3.3}$$

where lowercase letters denote the corresponding logarithmic value of output, labour and capital. The residual ϵ_{it} comprises measurement errors, m_{it}, and firm-specific productivity shocks, μ_{it}, such that $\epsilon_{it} = m_{it} + \mu_{it}$. In this analysis, both m_{it} and μ_{it} are assumed to be serially uncorrelated and only their sum ϵ_{it} is considered. The industry time-variant part $\lambda_{j(i),t}$ captures variations in productivity that are specific to a particular industry and that are left unexplained by the input variables. In this sense, $\lambda_{j(i),t}$ helps to ensure that outputs of firms are more readily comparable across industries. In particular, demand fluctuations induced by industry-specific business cycles may lead to variations in factor utilisation that are similar across firms of one industry. The resulting industry-specific changes of productivity are then captured by $\lambda_{j(i),t}$. While the industry-specific component $\lambda_{j(i),t}$ will be controlled for by including time-variant industry dummies, distorting effects from unobserved η_i and ϵ_{it} will be addressed by econometric techniques. I account for the fact that both η_i and ϵ_{it} may be correlated with the inputs if, for example, firms with a good man-

[11] With $j(i)$ denoting the industry j that firm i is operating in.

agement (i.e. a high η_i) are both more productive and more inclined to make use of capital input, or if a demand shock (high ϵ_{it}) raises both productivity as well as investment.

Several different empirical models are utilised to end up with consistent estimates of equation (3.3). As a starting point, I choose a simple *pooled OLS* estimation. Unfortunately, the simultaneity of inputs and outputs and measurement errors in the variables may induce substantial biased coefficients in this case.[12] To avoid potential correlation between unobserved firm specific fixed-effects (which sum up in the error term of the OLS estimation) and factor input choices, a *fixed-effects* estimation procedure (which uses only the variation within firms) would be an alternative, if panel data is available. One drawback, moreover, is that the nature of the fixed-effects estimator does not allow the estimation of time-invariant variables since it disregards the between-variance in the data.[13] Additionally, fixed-effects models are very inefficient in estimating the effect of variables that have very little within-variance, i.e. variables that only rarely change over time. For the analysis conducted in this chapter, this seems to be a problem since the indicator variable denoting if a firm is active in BPO is only rarely time-variant.[14] To deal with this issue, I refer to the *fixed-effects vector decomposition* model developed by Plümper and Troeger (2007).[15] Another approach to account for the simultaneity issue in production function estimations is presented by Olley and Pakes (1996). They introduce a semi-parametric method that allows to estimate the production function parameters consistently. The *Olley-Pakes* estimator solves the simultaneity issue by using the firm's investment decision to proxy unobserved productivity shocks.

The endogeneity of the explanatory variables can also be removed by an instrumental variable regression. In this respect, it is convenient to use GMM

[12] The simultaneity problem in a production function framework arises when there is contemporaneous correlation between the input factors and the error term. It can arise when the choice of inputs responds to shocks. This simultaneity problem violates the OLS assumptions for unbiased and consistent estimates.

[13] Hausman and Taylor (1981) show one way to deal with this problem by developing their so called Hausman-Taylor estimator, which became increasingly popular in recent years. More details about the assumptions of this estimator can be found in Wooldridge (2002).

[14] Additionally, two other variables I include in the empirical specification (the share of employees with a university degree and the share of employees working predominantly at a computerised workplace) change only slightly over the observed time span, which can be seen in Tables A3.2 and 3.1.

[15] The fixed-effects vector decomposition model is a three step procedure, where in the first step, a fixed-effects model is estimated to obtain the unit effects. The second step breaks down the unit effects into a part explained by the time-invariant and/or rarely changing variables and an error term, and the third stage re-estimates the first stage by pooled OLS including the time-invariant variables plus the error term of step two, which then accounts for the unexplained part of the unit effects.

estimations with internal instruments, i.e. other moments of the same variable (see for an application to production function Hempell, 2006). More precisely, the first differences of the explanatory variables are instrumented here by the levels of the lagged variables. However, the prediction power of the internal instruments could be small given the only minor changes in some of the variables (e.g. number of employees) from one year to another. That could evoke biases in the GMM estimator in first differences (Blundell and Bond, 1998). Therefore, I prefer the so-called *System-GMM* estimator by Arellano and Bover (1995). Here, the differences are instrumented again with lagged levels as internal instruments. The levels of the covariates are simultaneously instrumented by adequate lagged differences. The main advantage of this approach is that besides the temporary differences, differences among firms in levels are also taken account of in the estimation. That improves the information used for identifying the effect and usually enhances the precision of the estimator. A necessary condition for the System-GMM estimator is that the correlations between the unobserved fixed effects and the covariates remain constant over time (Arellano and Bover, 1995).

3.4 Data and Empirical Implementation

The firm-level data used for the empirical analysis are taken from a survey conducted by the Centre for European Economic Research (ZEW) between 2000 and 2007. It is a representative survey about the usage of information and communication technologies in firms of the German manufacturing and selected service sectors.[16] In each wave, a total of approximately 4,400 firms was interviewed. The data is stratified according to industries (seven manufacturing industries and seven service sectors), size (eight distinct classes) and region (East or West Germany). Besides a great amount of variables dealing with information and communication technologies, the ZEW ICT survey contains annual data on sales, number of employees (and their skill structure) and expenditures on gross investment. Merging all four existing waves of the survey results in an unbalanced panel structure because of unit- and item-non-response in important key variables. In the last wave, which was conducted in 2007, information about business process outsourcing was collected. Additionally to the current state of the firm regarding BPO, the survey also collected information on the starting year of various BPO activities.[17]

[16] The first wave of the so called ZEW ICT survey was conducted in the year 2000, the second wave followed two years later, the third wave in 2004 and the hitherto last survey wave took place in 2007.

[17] For a further discussion of this point, see page 93.

In order to conduct meaningful production function estimations, some of the available variables have to be transformed using external data sources. In the following, I will illustrate how these external data sources are used for transformation. As an output variable, the value of total sales is available from the ZEW ICT survey. Since the data set lacks reliable information about (the value of) intermediate inputs, I prefer to use firms' value added as a measure of output Y_{it} instead of sales. Using sales for output instead of value added without inclusion of the amount of intermediate inputs might lead to an omitted variable bias in the regressions since industries that operate rather at the end of the value chain (such as wholesale and trade) resort to intermediate goods more in terms of quantity than other industries do. To transform the value of total sales into value added and additionally deflating the corresponding outputs, I calculate the shares of real value added in nominal gross output at the NACE two-digit industry level.[18] The firm-specific data on sales are then multiplied by these industry-specific shares.[19] Labour input is measured as the year-average number of employees, including part time employees and apprentices.[20]

Capital input is, besides output and labour input, very crucial in estimating production functions. Unfortunately, the amount of gross fixed capital is not available from the survey. Instead, gross investment figures are reported by the firms. With appropriate accounting methods, explained below, one can construct total capital out of the investment information. Some firms did not report investment figures for one or more of the survey periods. To avoid loosing those observations because of this item non-response, I imputed investments for firms with missing values by multiplying the total number of employees with industry and year specific median investment intensities (investment per employee) obtained from the full survey sample (full cross-section) in each specific survey year. Additionally, for firms reporting zero investments, the value is replaced by the employee and year weighted ten percent quantile of the full survey sample. To justify this procedure, I assume that firms that report an investment value of zero have undertaken at least minor investments but this value is low and is

[18] For these calculations, I used tables 81000-0103 and 81000-0101 from the German Statistical Office.

[19] If Z_{it} and Y_{it} are sales and value added of firm i in period t, and if $Z_{j(i),t}$ and $Y_{j(i),t}$ are sales and value added aggregated over all firms of the same industry $j(i)$ that firm i is operating in, then the unknown value added of firm i is approximated by $Y_{it} \simeq Z_{it} \cdot Y_{j(i),t}/Z_{j(i),t}$.

[20] For some but not for all waves of the ICT survey, information about the share of part time employees at total employment is available. If this information were at hand for all waves, one could calculate (under assumptions, e.g. part time employees work on average half of their full-time equivalences) the year-average full-time equivalent number of employees for each firm.

approximated by zero.[21] In order to construct a capital stock from investment data, I use official producer price deflators for investment goods to deflate the investments of firm i. Given the deflated investments for capital, I apply the perpetual inventory method with constant, geometric depreciation to construct the capital stock. Accordingly, the capital stock K_{it} of firm i in period t results from investment I_{it} in the following way:

$$K_{it} \;=\; (1-\delta_{j(i)})K_{i,t-1} \;+\; I_{it} \tag{3.4}$$

with $\delta_{j(i)}$ denoting the industry-specific depreciation rates of capital stocks for firm i.[22] Since no information is available on the initial level of capital stock for each firm, I proxy this figure by using NACE two-digit capital per employee values multiplied by the number of employees of firm i (Gilhooly, 2009).[23,24]

The questionnaire of the ICT survey in 2007 asked firms about their outsourcing engagement in certain business activities, the starting year of this engagement and the extent of their outsourcing (fully or partly). The business process outsourcing variable is constructed as a dummy variable taking the value of one if firm i *completely* or *partially* outsources business processes to an external service provider and zero otherwise. The business processes under

[21] For the restricted sample (see page 3.4), 465 missing and 107 zero investment values are replaced.

[22] I calculated the depreciation rates $\delta_{j(i)}$ by industries as the shares of capital consumption in net fixed assets evaluated at replacement prices (time series 81000-0107 and 81000-0117 of the German Statistical Office). The unweighted mean over all industries amounts to 4.8 percent with a maximum of 16.6 percent in NACE 71 (renting of machinery and equipment) and a minimum of 2.3 percent in NACE 70 (real estate).

[23] To calculate industry (and time) specific per employee capital stock values, I use time series 81000-0117 and 81000-0111 provided by the German Statistical Office. Taking the average over the years 1998 to 2006, this value is highest in NACE 70 (real estate activities) with 7 525 604 euro per employee, followed by NACE 71 (renting of machinery and equipment) with 1 978 690 euro per employee and lowest in the other business activities sector (NACE 37) with 13 991 euro per employee.

[24] Alternatively, one could construct initial capital stocks employing the method proposed by Hall and Mairesse (1995). Under the assumption that investment expenditures on capital goods have grown at a similar, constant average rate g in the past in all firms, and the initial value of investment for firm i, $I_{i,1}$, is replaced by the average of the observed values of investment such that $I_{i,1} \simeq \frac{1}{T}\sum_{t=1}^{T} I_{it}$, equation (3.4) can be rewritten for period $t = 1$ (1999) by backward substitution in the following way: $K_1 = I_1 + (1-\delta)I_{-1} + (1-\delta)^2 I_{-2} + \ldots = \sum_{s=0}^{\infty} I_{-s}(1-\delta)^s = I_0 \sum_{s=0}^{\infty}\left[(1-\delta)/(1+g)\right]^s = I_1/(g+\delta)$. For two reasons, I rely rather on using weighted industry specific capital stocks for the initial period. First, since the employed panel is short in time dimension, investment outliers will significantly influence the initial capital stock calculation. Second, in order to derive the initial capital stocks out of investment data, assumptions about the pre-period growth rate g of investments have to be made. This figure could at best only be approximated by an economy wide (and not by an industry specific) growth rate.

Table 3.1: Descriptive statistics (restricted sample)

	1999		2001		2003		2006	
	Mean	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**
sales	55 914.54	5 112.92	55 457.87	7 000.00	69 432.82	6 200.00	80 533.31	7 000.00
value added	20 321.82	2 324.20	22 716.23	2 911.13	26 430.40	2 966.17	33 952.57	3 246.34
employees	253.50	36.00	248.52	50.00	227.07	45.00	277.24	50.00
capital	31 919.63	2 648.77	24 151.51	2 908.39	27 348.98	3 052.33	25 982.54	2 807.66
share university	0.20	0.12	0.19	0.10	0.20	0.11	0.20	0.11
share computer employees	0.44	0.35	0.48	0.40	0.45	0.35	0.45	0.40
log value added	7.80	7.75	8.03	7.98	8.03	8.00	8.16	8.09
log employees	3.85	3.58	3.98	3.91	3.90	3.81	3.92	3.91
log capital	7.91	7.88	8.02	7.98	8.09	8.02	8.07	7.94
value added per employee	75.58	49.18	93.24	50.81	101.60	54.82	124.34	63.33
capital per employee	262.14	49.62	176.67	46.00	229.58	56.03	275.78	53.98
number of firms	273		698		698		698	

Note: Monetary values are in 1 000 euros in prices of 2000.
Source: ZEW ICT survey and own calculations.

consideration are (i) *marketing*, (ii) *procurement*, (iii) *customer services*, (iv) *sales and distribution*, (v) *IT-infrastructure*, (vi) *software programming* and (vii) *external provision of computing capacity*. Figure A3.5 (in the appendix) gives an overview of how intensively German firms (with five and more employees) outsource these processes, divided into manufacturing and service industries.

For the empirical analysis, two data sets are generated which are in the following referred to as *full sample* and *restricted sample*. In both samples, firms operating in the *data processing and telecommunication industry* are dropped because business process service vendors are typically categorised in this industry and presumably show a different behaviour regarding BPO than firms belonging to other industries. The full sample comprises all observations available for the survey years 2000, 2002, 2004 and 2007. Note that since information about BPO is essential for the analysis conducted in this chapter and BPO information was only collected in the 2007 wave, all firms included in the (full and restricted) sample must have been observed in the year 2007. The full sample then comprises 5 980 observations referring to 2 856 firms. In order to apply System-GMM estimations, I need at least three consecutive observations per firm. Therefore, I consider for the restricted sample only firms with a minimum of three observations (2007, 2004 and 2002) and additionally, if available, the firm observation in 2000. The resulting restricted sample consists of 678 firms with a total of 2 297 observations. Descriptive statistics for the full and the restricted sample can be found in Tables A3.2 (in the appendix) and 3.1, respectively. For each survey year, the mean and the median value of inputs and outputs are presented.[25]

In the following, I will concentrate on the restricted sample in Table 3.1. Besides sales and value added on the output side and employees and capital as inputs to the production process, the table reports the share of highly qualified employees with at least an university degree and the share of employees working predominantly at a computerised workplace. Both variables are additionally used on the input side to control for labour heterogeneity (share university) and information technology intensity of the firm (share computer employees). Both variables are on average quite persistent over the observed sample period with the mean value of *share university* almost unchanged at around 0.2. The average share of employees working with a computer is always more than twice as high with values between 0.44 and 0.48. Average firm size measured in total employees is 253.5 in 1999 and decreases thereafter until a rise to 277.2 employees in 2006. Median firm size is substantially lower and between 36 and 50 employees. Value added and capital per employee are reported in the third and second to last row of Table 3.1. Average value added per employee is

[25] Note, that the values always refer to the year prior to the year in which the survey was conducted, so the survey in 2000 reports quantitative values of the year 1999.

steadily increasing, being almost 65 percent higher in 2006 compared to 1999. The median value is also increasing over time but by far not as strong as the mean value. An average workplace is equipped with capital worth 262 140 euro in 1999. Thereafter, the intensity is lower but rising again to an average value of 275 777 euro per employee.[26] Again, the median value is substantially lower and quite stable over the observed period.

Table 3.2: Descriptive statistics (restricted sample) – BPO versus non-BPO firms

	All firms		**BPO firms**		**non-BPO firms**	
	Mean	**Median**	**Mean**	**Median**	**Mean**	**Median**
1999:						
employees	253.50	36.00	319.17	40.00	213.08	35.00
value added per employee	75.58	49.18	92.98	51.67	64.88	47.90
capital per employee	262.14	49.62	364.95	49.62	198.87	49.62
number of firms	273		104		169	
2001:						
employees	248.52	50.00	306.57	60.00	185.99	40.00
value added per employee	93.24	50.81	98.51	57.58	87.57	47.11
capital per employee	176.67	46.00	178.86	48.81	174.31	44.71
number of firms	698		362		336	
2003:						
employees	227.07	45.00	279.67	55.00	145.19	32.00
value added per employee	101.60	54.82	109.30	61.67	89.61	47.23
capital per employee	229.58	56.03	259.06	61.39	183.70	52.23
number of firms	698		425		273	
2006:						
employees	277.24	50.00	349.90	60.00	100.05	25.00
value added per employee	124.34	63.33	116.55	68.83	143.34	53.72
capital per employee	275.78	53.98	274.10	54.33	279.87	50.40
number of firms	698		495		203	

Note: Monetary values are in 1 000 euros in prices of 2000.
Source: ZEW ICT survey and own calculations.

[26] Figures published by the German Statistical Office reveal an average capital intensity in Germany of 259 000 euro for 1999, 266 000 euro for 2001 and 280 000 euro for 2003 (all measured in prices of 1995).

Table 3.2 compares business process outsourcing and non-outsourcing firms (for each year). One can clearly see that outsourcing firms are on average (and in the median) always larger than non-outsourcing firms. Additionally, mean value added per employee is considerably higher in the years 1999, 2001 and 2003 for outsourcing firms, while the opposite holds true for the year 2006. By contrast, the median value is always smaller for non-outsourcing firms. The same data structure can be observed for capital per employee. The last lines for each year in Table 3.2 give information about the number of observations in the restricted sample, and the division of those observations between business process outsourcing and non-outsourcing firms. The largest group of observations in the restricted sample stems from the *metal and machine construction industry* with 13.4 percent as indicated by Table 3.3. *Wholesale trade* contributes the smallest share of observations with 4.2 percent (or 99 observations) to the restricted sample.[27] The second part of Table 3.3 presents the distribution of outsourcing and non-outsourcing firms by industry and year of observation.

Table 3.3: Share of observations by industry and BPO intensity

			thereof ... (in %)			
Industry	**Share of obs. (in %)**	**# of obs.**	**BPO 1999**	**BPO 2001**	**BPO 2003**	**BPO 2006**
consumer goods	8.11	192	50.00	56.67	61.67	71.67
chemical industry	6.21	147	52.38	69.05	73.81	83.33
other raw materials	7.69	182	13.04	43.40	49.06	69.81
metal and machine construction	13.43	318	30.30	47.37	57.89	71.58
electrical engineering	9.00	213	30.00	36.07	50.82	57.38
precision instruments	9.51	225	29.17	44.78	58.21	68.66
automobile	5.96	141	33.33	65.00	75.00	87.50
wholesale trade	4.18	99	50.00	65.52	75.86	79.31
retail trade	8.45	200	47.83	57.63	64.41	71.19
transport and postal serv.	7.39	175	36.36	47.06	58.82	62.75
banks and insurances	5.87	139	69.23	71.43	78.57	88.10
technical services	7.73	183	33.33	38.89	44.44	53.70
other business-related serv.	6.46	153	55.56	55.56	64.44	73.33
Total	100.0	2 367	38.10	51.86	60.89	70.92

Source: ZEW ICT survey and own calculations.

[27] For a detailed description and composition of the sectors included in the survey, see Table A3.4 (in the appendix).

Taking a look at Figure A3.6, where the share of firms which start with BPO in each year in the restricted sample is reported, one can verify that basically in the mid 1990s, firms started to outsource their business services. With one exception, the distribution over the following years is fairly equal.[28] Looking at the outsourcing intensity in 1999, the sector *other raw material* shows the lowest share of outsourcing firms with only 13.0 percent. The most active sector in outsourcing business processes is the *bank and insurance* sector with 69.2 percent in 1999. This sector also remains most active in the following years with an increase of 18.9 percentage points from 1999 to 2006. The sector *other raw material* shows the highest increase with 56.8 percentage points, albeit starting from a low level (see above). Altogether, in 1999, 38.1 percent of the firms are outsourcing and this share increases to 70.9 percent in 2006.

Table 3.4 shows again descriptive statistics of labour productivity (value added per employee), separately for firms involved in BPO and firms not involved in BPO, followed by a t-test of mean log labour productivity between BPO and non-BPO firms. As I already mentioned earlier, the mean of labour productivity in the first three waves is always higher in the outsourcing case. For the last wave, the opposite is true. Looking at the mean of the logarithmised values for both groups of firms, mean value added per employee is in every year higher for the outsourcing firms. t-tests confirm that this difference is highly significant in all years exept the first one, as can be recognised in the bottom part of Table 3.4. This gives a first hint that business process outsourcing constitutes somehow positive productivity differences between outsourcing and non-outsourcing firms.

One final note remains on the issue of endogeneity of BPO. It might be the case that there is self-selection of firms into BPO, so that already successful firms are more inclined to BPO than less successful firms. To explore this issue, I compare for each year of observation the mean value and the distribution of labour productivity of firms which either just started with BPO in the survey year or the year thereafter (in this paragraph these are named BPO firms) with firms that either started BPO later or never outsourced any business services.[29] For example, labour productivity in 1999 is compared among firms that started outsourcing in 1999 or in 2000 and firms that either started to outsource after 2000 or never outsourced at all. If the mean value and especially the distribution

[28] The spike in 2000 might be caused by rounding of the interviewee when they were not sure in which year their company exactly started to outsource. This peculiarity can also be observed in other full decade years like 1990 or 1980.

[29] Thereby, I am assuming that starting with BPO in the year labour productivity is observed does not have an impact on the same. This is a plausible assumption, since it needs some time until productivity effects from BPO are actually incorporated due to initial starting problems and adjustment efforts which have to be made.

Table 3.4: Comparison of mean log labour productivity (value added per employee) of BPO and non-BPO firms

			Quantile			
	Mean	**STD**	**10%**	**50%**	**90%**	**N**
log labour productivity$_{w/\ BPO,\ 1999}$	4.0402	0.9614	2.9821	3.9448	5.2273	104
log labour productivity$_{w/o\ BPO,\ 1999}$	3.8881	0.7377	2.9086	3.8692	4.7256	169
log labour productivity$_{w/\ BPO,\ 2001}$	4.1639	0.8763	3.2651	4.0532	5.3712	362
log labour productivity$_{w/o\ BPO,\ 2001}$	3.9335	0.9009	2.9200	3.8526	5.0093	336
log labour productivity$_{w/\ BPO,\ 2003}$	4.2491	0.8770	3.3156	4.1219	5.4636	425
log labour productivity$_{w/o\ BPO,\ 2003}$	3.9491	0.8323	3.0679	3.8550	4.9936	273
log labour productivity$_{w/\ BPO,\ 2006}$	4.3215	0.8787	3.4151	4.2316	5.5462	495
log labour productivity$_{w/o\ BPO,\ 2006}$	4.0421	0.9318	3.0381	3.9838	5.0681	203

t-test on the equality of the means of **log labour productivity**

H_0: mean(w/ BPO, 1999) - mean(w/o BPO, 1999) =	diff $= 0 \rightarrow t = 1.4709$
H_1:	diff $\neq 0 \rightarrow [\ p > \lvert t \rvert\ ] = 0.1425$
H_0: mean(w/ BPO, 2001) - mean(w/o BPO, 2001) =	diff $= 0 \rightarrow t = 3.4247$
H_1:	diff $\neq 0 \rightarrow [\ p > \lvert t \rvert\ ] = 0.0007$
H_0: mean(w/ BPO, 2003) - mean(w/o BPO, 2003) =	diff $= 0 \rightarrow t = 4.4980$
H_1:	diff $\neq 0 \rightarrow [\ p > \lvert t \rvert\ ] = 0.0000$
H_0: mean(w/ BPO, 2006) - mean(w/o BPO, 2006) =	diff $= 0 \rightarrow t = 3.7471$
H_1:	diff $\neq 0 \rightarrow [\ p > \lvert t \rvert\ ] = 0.0002$

Note: Labour productivity is value added per employee in 1 000 euro in prices of 2000.
Source: ZEW ICT survey and own calculations.

is not significantly different between those two groups, this would give some evidence for the exogeneity of BPO. Mean values are compared by using a t-test and distributional equality (or differences) is revealed by applying the non-parametric Kolmogorov-Smirnov test. Results are presented in Table A3.1 (in the appendix). If one looks at the differences in the mean values, there are actually significant differences in 2001 and 2003 as stated in column 3. For 1999 and 2006, no significant difference can be observed, with a mean value for non-outsourcing firms even larger than for BPO firms. Moving one column to the right in Table A3.1 gives the p-value of the overall Kolmogorov-Smirnov test of equal distribution. For this test, only the distribution for log labour productivity in 2003 is significantly different for BPO and non-BPO firms, in all the other years, equal distributions cannot be rejected on all conventional

significance levels. Although the results are not as clear-cut as desired, they still give some support for the exogeneity assumption of BPO.

3.5 Empirical Results

This section presents the estimation results achieved by using different (panel) estimation techniques already mentioned in Section 3.3 to end up with a reliable and consistent estimate of the impact associated to business process outsourcing on productivity.

In Table 3.5, the estimation results for the restricted sample are reported using four different estimation techniques. The first two columns contain the results for the pooled ordinary least square regression. While in column 1, the variable indicating if a firm is active in business process outsourcing is left out, the BPO dummy is included in the second column. In both estimations, the labour and capital input coefficients are highly significant, reaching values of 0.829 (0.824) for labour input and 0.196 (0.194) for capital input. As can easily be verified, there is no significant difference in the coefficients of the two input variables between the estimation with and without a BPO dummy. Looking further at the specification including BPO, the coefficients of the share of employees with at least a university degree and the share of employees working at a computerised workplace are also economically and statistically highly significant. Increasing the share of employees with a university degree (working at a computerised workplace) by one percentage point increases log value added by 0.588 (0.578) percent.[30] The size of labour and capital input is not affected by the inclusion of these additional regressors (comparable regressions are not reported) which account for the heterogeneity of labour and the ICT intensity of the firms. Inclusion of the BPO indicator yields a positive and significant coefficient of 0.142 as can be seen in column 2. According to this pooled OLS regression, there is indeed a positive productivity effect for the firms outsourcing business services. This involvement in the external provision of business services shows an effect of approximately 18.28 percent.[31] Additionally, the coefficient for the dummy variable indicating if a firm is located in East Germany is significantly negative, reflecting lower productivity in East Germany. Since the pooled OLS estimates are possibly biased because observations of the same firm in different years are considered as independent and unobserved heterogeneity cannot be taken into account, these specifications are basically used as a reference point

[30] Note that a one percentage *point* increase corresponds to a 5.1 percent increase of the share of employees with a university degree and a 2.2 percent increase of the share of employees working at a computerised workplace each evaluated at the overall mean value.

[31] Note that $(exp(0.1421) - 1) \cdot 100 = 15.27$ percent.

Table 3.5: Estimation results (restricted sample)

	Pooled OLS		Fixed-Effects		Olley-Pakes		System-GMM	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log labour	0.8292***	0.8241***	0.4614***	0.4618***	0.7823***	0.7816***	0.8923***	0.8892***
	(0.0415)	(0.0410)	(0.0096)	(0.0096)	(0.0516)	(0.0459)	(0.0785)	(0.0779)
log capital	0.1961***	0.1936***	0.0766***	0.0760***	0.2372***	0.2297***	0.1995**	0.1990**
	(0.0391)	(0.0389)	(0.0081)	(0.0081)	(0.0628)	(0.0530)	(0.0779)	(0.0779)
share university	0.5877***	0.5817***	0.4242***	0.4318***	0.6053***	0.6003***	0.5592***	0.5592***
	(0.1735)	(0.1709)	(0.0408)	(0.0408)	(0.1680)	(0.1534)	(0.1230)	(0.1216)
share computer empl.	0.5780***	0.5679***	0.5519***	0.5090***	0.5708***	0.5602***	0.3934***	0.3876***
	(0.0906)	(0.0908)	(0.0282)	(0.0283)	(0.0918)	(0.1007)	(0.0676)	(0.0676)
East	-0.3900***	-0.3873***	-0.5425***	-0.5251***	-0.3818***	-0.3794***	-0.3712***	-0.3706***
	(0.0706)	(0.0703)	(0.0182)	(0.0182)	(0.0739)	(0.0726)	(0.0702)	(0.0700)
BPO		0.1421***		0.4017***		0.1359**		0.0861*
		(0.0531)		(0.0156)		(0.0534)		(0.0442)
constant	3.7137***	3.6843***	5.6346***	5.8511***			2.6454***	2.6009***
	(0.2097)	(0.2087)	(0.1125)	(0.1093)			(0.4063)	(0.4025)
Time and industry dummies	yes	yes	yes	yes	yes	yes	yes	yes
AR(1)							0.0000	0.0000
AR(2)							0.9255	0.9250
Hansen *J*-test							0.9002	0.9130
# of instruments							65	66
R^2	0.8184	0.8197	0.9745	0.9745	0.8201	0.8214	0.8168	0.8180
# of observations	2367	2367	2367	2367	2367	2367	2367	2367
# of firms	698	698	698	698	698	698	698	698

Note: Dependent variable log value added. *,** and *** indicate significance at the 10%, 5% and 1% level respectively. Robust standard errors are reported in parentheses. For the autocorrelation tests (AR(1) and AR(2)) and the Hansen *J*-test, *p*-values are reported. **Source:** ZEW ICT survey and own calculations.

to compare the outcomes with more appropriate estimation techniques which I will present in the following.

The third and fourth column of Table 3.5 contain the results of a fixed-effects vector decomposition estimation as proposed by Plümper and Troeger (2007).[32] The coefficients on all variables are strikingly different compared to the corresponding results for the pooled OLS regressions. The coefficients for labour and capital, albeit highly significant, are only half as large as in the OLS case, needless to say that a constant return to scale assumption in the input factors labour and capital is rejected. The university degree and the computer employment share also show a reduced magnitude, but with 0.431 and 0.509 (in the specification with BPO), those lie within the range of the equivalent OLS specification. With 0.401, the highly significant coefficient of the BPO Dummy is completing those considerably different results. Fixed-effects estimation requires the assumption that the unobserved input or productivity of firm i is constant across time. This assumption might be violated by the time span of 7 years regarded in this analysis.

Olley and Pakes (1996) (OP) suggest a different approach. Rather than allowing for time-constant firm heterogeneity, they show that investment can be used as a proxy variable for unobserved, time-varying productivity. Specifically, productivity can be expressed as an unknown function of capital and investment (when investment is strictly positive). As opposed to the original OP estimator, I do not control for firm-exit, since information about that is not available. The results are presented in columns 5 and 6 of Table 3.5.[33] Comparing the coefficients for capital and labour with the results achieved by pooled OLS, we see a slight decrease in both coefficients (for the specification with as well as for the specification without BPO). In contrast, the share of university employees is slightly higher in the OP regressions, whereas the share of computer employees remains almost unchanged. Turning the focus to the variable of main interest in this analysis, the BPO indicator, we observe a coefficient which is smaller and less significant than in the pooled OLS regression and which amounts to 0.136. A recalculation of the effect on value added results on average in a 14.56 percent higher outcome for outsourcing firms.

The endogeneity problem of labour and capital is further addressed in the system-GMM regressions. Here, the lagged endogenous variables are used as instruments. Labour and capital are regarded as endogenous variables, the dummies for industry, time, and the location of the firm (East or West Germany) are assumed to be exogenous. Besides that, the BPO dummy variable is assumed

[32] The Stata® estimation command `xtfevd`, provided by Plümper and Troeger, is used.

[33] The regressions are performed using the additional `opreg` command in Stata® provided by Yasar et al. (2008).

to be exogenous. System-GMM estimation results[34] are presented in the last two columns of Table 3.5, where as usual, a basic production function without the BPO-'input' variable is reported first. The results for the labour and capital inputs are again significant. While labour is significant at the one percent level, the significance of capital is somewhat lower. In absolute terms, we observe in the System-GMM specification the highest output elasticity with respect to labour over all specifications under consideration. With 0.889 (in the BPO specification) the elasticity lies 13.7 percent higher than in the OP case and 7.9 percent higher compared with the OLS result. The opposite is true for the capital coefficient with regard to the OP results. In System-GMM, the capital coefficient is lower and amounts to about the value achieved by pooled OLS with 0.199 (again in the BPO specification). While the coefficient for the share of university employees remains in the broad range of the previous results, the value for the share of computer employees falls to 0.388, which is significantly below the previously achieved values. The inclusion of the BPO indicator in column 8 shows a positive and significant effect, albeit also smaller in economic terms than previous regression results suggested. The estimated coefficient of 0.086 results in a productivity increase of around 9.0 percent. In both System-GMM specifications, the Hansen test of overidentifying restrictions does not reject the joint validity of the instruments used at any conventional significance level.[35] The AR(1) and AR(2) tests reported at the bottom of column 7 and 8 are the Arellano-Bond test for autocorrelation. It has a null hypothesis of no autocorrelation and is applied to the differenced residuals.[36] There is significant first order correlation (of the first differenced residuals) and no second order correlation at the usual significance levels. This result further indicates the validity of the applied instruments.

To make some robustness checks of the results achieved so far, I am repeating the regressions just presented by using the full data sample as described

[34] The estimations are carried out using the additional `xtabond2` command in Stata® (Roodman, 2009). I applied the available two-step estimation variant which is asymptotically more efficient than the one-step alternative. Unfortunately, the reported two-step standard errors tend to be severely downward biased (Arellano and Bond, 1991; Blundell and Bond, 1998). To resolve this problem, Windmeijer's adjustment process for variances is additionally incorporated (Windmeijer, 2005). This method helps to make the two-step system-GMM estimation more efficient than the one-step estimation.

[35] Additionally, the Sargan test would be available. But since this test is not robust to heteroskedasticity or autocorrelation, I choose to report the Hansen *J*-test, which is robust (but might be weakened by many instruments).

[36] The test for AR(1) process in first differences usually rejects the null hypothesis, but this is expected since $\Delta\epsilon_{it} = \epsilon_{it} - \epsilon_{i,t-1}$ and $\Delta\epsilon_{i,t-1} = \epsilon_{i,t-1} - \epsilon_{i,t-2}$ both include $\epsilon_{i,t-1}$. The test for AR(2) in first differences is more important, since it will detect autocorrelation in levels.

Table 3.6: Estimation results (restricted sample)

Industry left out from regression...	BPO coeff.	AR(1)	AR(2)	Hansen *J*-test	# of instr.	# of obs.	# of firms
consumer goods	0.0856*	0.0000	0.7932	0.8815	62	2175	638
	(0.0476)						
chemical industry	0.0859*	0.0000	0.8722	0.7410	62	2220	656
	(0.0478)						
other raw materials	0.0862*	0.0000	0.7775	0.8380	62	2185	645
	(0.0468)						
metal and machine construction	0.0905*	0.0000	0.9830	0.8662	62	2049	603
	(0.0501)						
electrical engineering	0.0930*	0.0000	0.9229	0.7993	62	2154	637
	(0.0475)						
precision instruments	0.1079**	0.0000	0.9311	0.8158	62	2142	631
	(0.0488)						
automobile	0.0880*	0.0000	0.8992	0.8862	62	2226	658
	(0.0461)						
wholesale trade	0.0885*	0.0000	0.9041	0.9050	62	2268	669
	(0.0459)						
retail trade	0.0807*	0.0000	0.6829	0.8961	62	2167	639
	(0.0441)						
transport and postal services	0.0783*	0.0000	0.8842	0.8587	62	2192	647
	(0.0450)						
banks and insurances	0.0766*	0.0000	0.9632	0.8905	62	2228	656
	(0.0445)						
technical services	0.0973**	0.0000	0.8921	0.8907	62	2184	644
	(0.0449)						
other business-related services	0.0836*	0.0000	0.5653	0.9809	62	2214	653
	(0.0426)						

Note: System-GMM estimation with dependent variable log value added. *,** and *** indicate significance at the 10%, 5% and 1% level respectively. Robust standard errors are reported in parentheses. For the autocorrelation tests (AR(1) and AR(2)) and the Hansen *J*-test, *p*-values are reported. All regressions are specified according to Table 3.5, column 8. **Source:** ZEW ICT survey and own calculations.

in Section 3.4.[37] Summary statistics for the full sample are shown in Table A3.2 and the estimation results are reported in Table A3.3 (in the appendix). Compared to the restricted sample, the number of total observations increased almost twice and the number of firms comprised by these observations increased more than four times. For the labour and capital input coefficients, this increase seems to have no great effects. Only the capital elasticity in the fixed-effects estimation decreases to an unreliable but still significant value of 0.01. In the pooled OLS and the Olley-Pakes regressions, the elasticities of the share of university and computer employees reduces sometimes substantially, but still all coefficients are highly significant. Let us turn to the BPO results. In all three regressions, the outcome for BPO is positive and highly significant but higher compared to the restricted sample.[38] It seems that although estimation results are quite similar, the restricted sample tends to underestimate the effect of BPO.

To assure that the results from the restricted sample are not driven by a specific industry, a further check is undertaken. Therefore, the System-GMM estimation is run by excluding each industry separately. Table 3.6 presents the results thereof, where only the BPO coefficients are reported. None of the regressions show an insignificant coefficient for BPO. In some cases (precision instruments industry and technical services), the significance of BPO in the System-GMM results is even raised. This assures that there is no specific industry effect which influences the results achieved.

3.6 Concluding Remarks

The existing empirical literature concerning the relationship between business process outsourcing and productivity is very scarce. In addition, the literature on the much broader field of service outsourcing gives a diverse picture concerning the performance effects of outsourcing. The aim of this chapter is to close this gap by presenting a comprehensive analysis of the effects of BPO on firm-level productivity in Germany. Therefore, an augmented production function approach is used which takes account of firms' BPO activities. For the empirical analysis, four different estimation techniques are employed: a pooled OLS estimation, a fixed-effects vector decomposition estimation, an Olley and Pakes approach and a System-GMM estimation. The System-GMM approach

[37] Because of the necessity of the System-GMM estimator to have at least three consecutive observation per firm available, I have to exclude System-GMM in the full sample estimations. Indeed, System-GMM estimation was the reason for constructing the restricted sample.

[38] For pooled OLS, the increase amount to about 18 percent, for fixed-effects it is about 29 percent and finally the increase for the Olley-Pakes estimation lies by 14 percent.

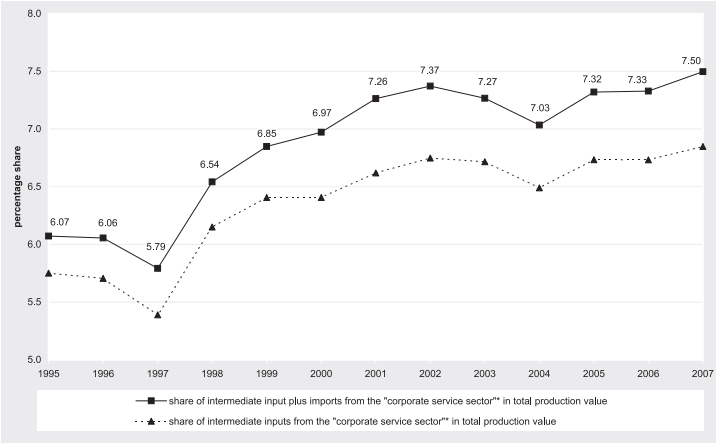
is the preferred method by the author because of its comprehensive accountants of unobserved firm effects, measurement errors in the variables and simultaneity of inputs and output. The results show that business process outsourcing has a considerably positive and significant effect on firm-level productivity, which accounts on average for a 9 percent productivity increase for firms sourcing out business processes. Therefore, outsourcing business processes to external service providers seems to be a good choice. It allows the management of the firm to focus more on the core business of the company. Moreover, the qualified and experienced work of the external service provider and the possibly achieved cost savings finally result in an improved business performance.

There are some potential drawbacks of this study which need to be addressed and leave room for further research. First of all, the potential endogeneity of business process outsourcing is not definitively resolved. Descriptive evidence shows that firms, before they start outsourcing, are not significantly different in terms of labour productivity. Nevertheless, it would be helpful to have an instrument to control for potential endogeneity in BPO. Since the survey does not provide such an instrument, this aspect has to be left for further research. Second, since the vast majority of business process outsourcing took place after 2000, this study captures the rather short and midterm effects of BPO. It would be interesting to have further observations in the future to capture the long run effects, too. There are some authors arguing that outsourcing, especially of knowledge intensive processes, in the long run reduces the firm knowledge base significantly which then results in reduced performance. Clarification of this issue also has to be left for future research.

3.7 Appendix

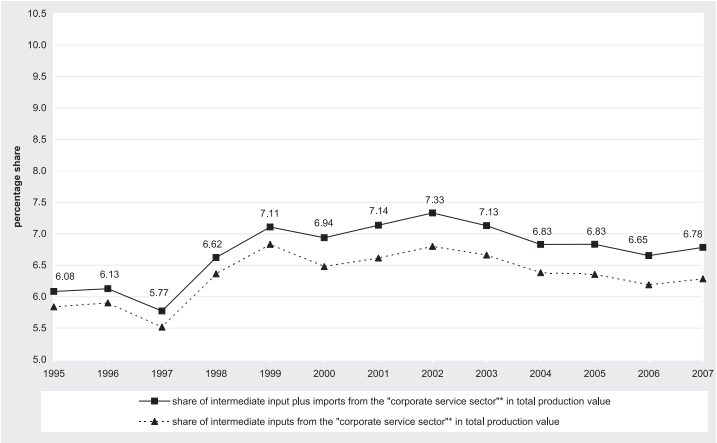
3.7.1 Tables and Figures

Figure A3.1: Share of intermediate inputs from the "corporate service sector"* in total production value (Germany, 1995-2006)



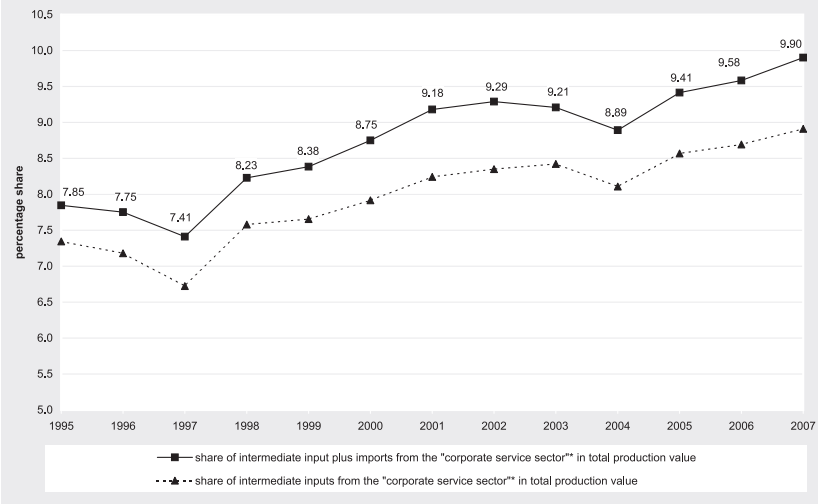
Note: *The "corporate service sector" comprises the sectors "computer and related activities" (NACE 72), "research and development" (NACE 73) and "other business activities" (NACE 74).
Source: Based on input-output tables provided by the Germany Statistical Office and authors' calculations.

Figure A3.2: Share of intermediate inputs from the "corporate service sector"* in total production value of manufacturing industries (Germany, 1995-2006)



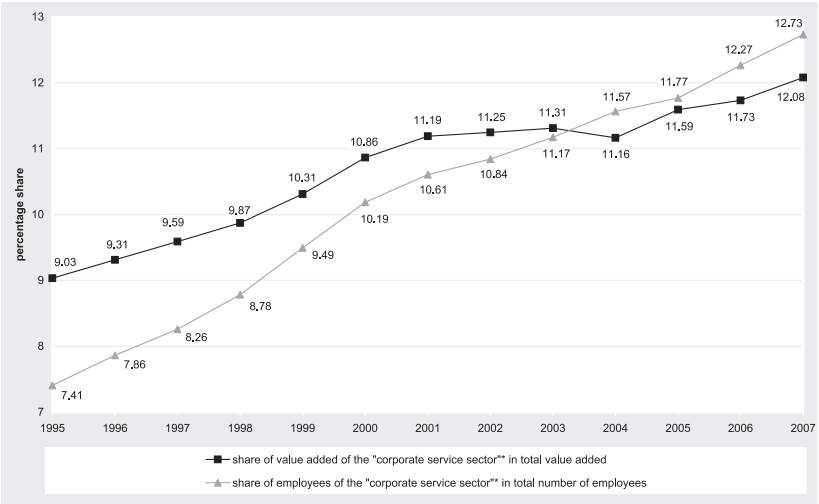
Note: *The "corporate service sector" comprises the sectors "computer and related activities" (NACE 72), "research and development" (NACE 73) and "other business activities" (NACE 74).
Source: Based on input-output tables provided by the Germany Statistical Office and authors' calculations.

Figure A3.3: Share of intermediate inputs from the "corporate service sector"* in total production value of service industries (Germany, 1995-2006)



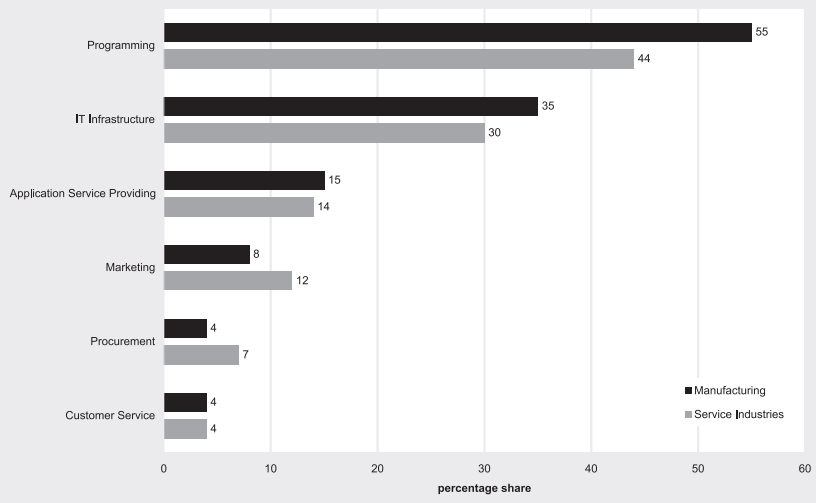
Note: *The "corporate service sector" comprises the sectors "computer and related activities" (NACE 72), "research and development" (NACE 73) and "other business activities" (NACE 74).
Source: Based on input-output tables provided by the Germany Statistical Office and authors' calculations.

Figure A3.4: Share of value added (employees) from the "corporate service sector"* in total value added (employees) (Germany, 1995-2006)



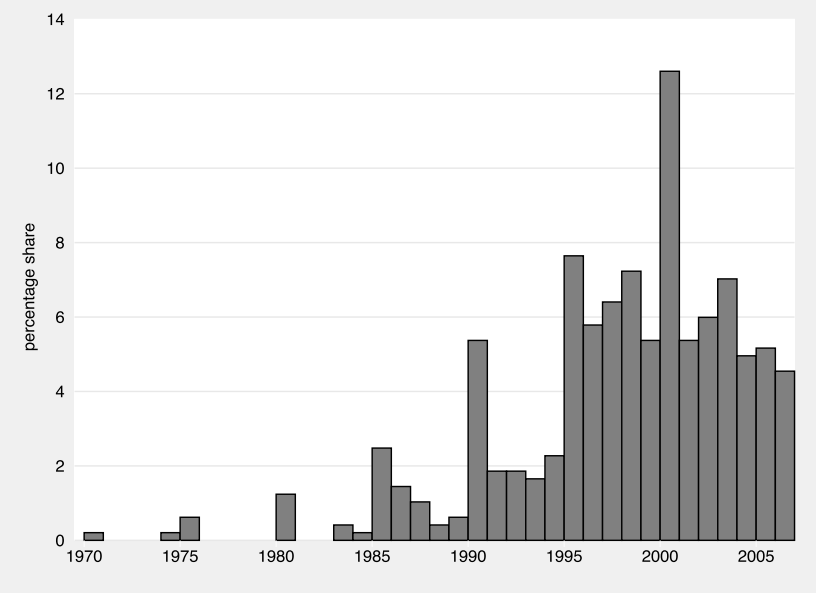
Note: *The "corporate service sector" comprises the sectors "computer and related activities" (NACE 72), "research and development" (NACE 73) and "other business activities" (NACE 74).
Source: The share of value added is based on input-output tables and the share of employees is based on Table 81000-0111, both provided by the Germany Statistical Office, and authors' calculations.

Figure A3.5: Share of firms outsourcing business processes in Germany 2007



Note: Results are representative for German firms with five and more employees.
Source: ZEW ICT survey, first quarter 2007.

Figure A3.6: Starting year of business process outsourcing



Note: Based upon the number of firms (N = 678) in the restricted sample.
Source: ZEW ICT survey and own calculations.

Table A3.1: Ex-ante comparison of log labour productivity (value added per employee) of BPO and non-BPO firms

				Kolmogorov-Smirnov test (*p*-value)		
	Mean with BPO	**Mean without BPO**	***t*-test (*p*-value)**	H_0: equal dist. for firms w/ and w/o BPO	H_0: differences favourable for firms w/ BPO	H_0: differences favourable for firms w/o BPO
log labour productivity$_{1999}$	3.8669 (0.8331)	3.9100 (0.7739)	0.7918	0.5513	0.2810	0.7877
# of firms	31	148				
log labour productivity$_{2001}$	4.2049 (0.8703)	3.9243 (0.9009)	0.0312	0.2191	0.9670	0.1097
# of firms	55	317				
log labour productivity$_{2003}$	4.2488 (0.7815)	3.9491 (0.8423)	0.0109	0.0111	0.9653	0.0056
# of firms	58	259				
log labour productivity$_{2006}$	4.2561 (0.7314)	4.0353 (0.9262)	0.2003	0.1441	0.9195	0.0721
# of firms	22	212				

Note: In this table, firms with BPO are firms that started with BPO in the year labour productivity is observed or in the following year. Firms without BPO are firms that either started with BPO two years after labour productivity is observed or never started with BPO. Labour productivity is value added per employee in 1 000 euro in prices of 2000. Standard deviations are reported in parenthesis.
Source: ZEW ICT survey and own calculations.

Table A3.2: Descriptive statistics (full sample)

	1999		2001		2003		2006	
	Mean	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**
sales	104 688.22	6 198.66	134 574.81	7 000.00	86 187.48	5 800.00	73 411.43	5 000.00
value added	40 837.60	2 824.18	57 289.69	3 040.80	33 302.32	2 702.54	31 662.40	2 369.50
employees	384.94	48.00	393.99	50.50	238.35	45.00	240.77	40.00
capital	52 170.02	3 012.75	78 556.84	3 039.69	31 885.81	2 929.76	40 151.96	2 472.07
share university	0.21	0.12	0.19	0.10	0.20	0.10	0.19	0.10
share computer employees	0.44	0.38	0.47	0.40	0.44	0.33	0.43	0.30
log value added	8.16	7.95	8.12	8.02	8.01	7.90	7.96	7.77
log employees	4.09	3.87	4.03	3.92	3.89	3.81	3.83	3.69
log capital	8.19	8.01	8.07	8.02	8.06	7.98	7.98	7.81
value added per employee	188.96	51.29	104.70	52.50	107.71	54.09	119.84	57.89
capital per employee	319.17	49.62	206.97	46.00	255.33	54.00	947.86	53.89
number of firms	720		1 046		1 417		2 881	

Note: Monetary values are in 1 000 euros in prices of 2000.
Source: ZEW ICT survey and own calculations.

Table A3.3: Estimation results (full sample)

	Pooled OLS		Fixed-Effects		Olley-Pakes	
	(1)	(2)	(3)	(4)	(5)	(6)
log labour	0.8348***	0.8277***	0.5269***	0.5269***	0.7657***	0.7630***
	(0.0202)	(0.0201)	(0.0075)	(0.0075)	(0.0219)	(0.0233)
log capital	0.2055***	0.2022***	0.0169***	0.0171***	0.1865**	0.1781**
	(0.0187)	(0.0186)	(0.0064)	(0.0064)	(0.0781)	(0.0753)
share university	0.4838***	0.4854***	0.4140***	0.4333***	0.4507***	0.4516***
	(0.0942)	(0.0930)	(0.0358)	(0.0358)	(0.0989)	(0.0962)
share computer	0.6580***	0.6435***	0.6361***	0.5427***	0.6417***	0.6286***
employees	(0.0567)	(0.0564)	(0.0242)	(0.0243)	(0.0589)	(0.0584)
East	-0.3522***	-0.3488***	-0.5738***	-0.5497***	-0.3456***	-0.3428***
	(0.0351)	(0.0350)	(0.0144)	(0.0143)	(0.0312)	(0.0334)
BPO		0.1679***		0.5170***		0.1548***
		(0.0298)		(0.0137)		(0.0321)
constant	3.6964***	3.6719***	6.2633***	5.5825***		
	(0.1631)	(0.1605)	(0.0866)	(0.0857)		
Time and ind. dummies	yes	yes	yes	yes	yes	yes
R^2	0.8128	0.8144	0.9684	0.9684	0.8140	0.8154
# of observations	6064	6064	6064	6064	6064	6064
# of firms	2881	2881	2881	2881	2881	2881

Note: Dependent variable log value added. *,** and *** indicate significance at the 10%, 5% and 1% level respectively. Robust standard errors are reported in parentheses.
Source: ZEW ICT survey and own calculations.

Table A3.4: Industry classification

Industry	Explanation	NACE
consumer goods		
	manufacture of food products, beverages and tobacco	15-16
	manufacture of textiles and textile products	17-18
	manufacturing of leather and leather products	19
	manufacture of wood and wood products	20
	manufacturing of pulp, paper and paper products; publishing and printing	21-22
	manufacturing n.e.c.	36-37
chemical industry		
	manufacture of coke, refined petroleum products and nuclear fuel	23
	manufacture of chemicals, chemical products and man-made fibres	24
other raw materials		
	manufacture of rubber and plastic products	25
	manufacture of non-metallic mineral products	26
	manufacture of basic metal	27
metal and machine construction		
	manufacture of fabricated metal products (except machinery and equipment)	28
	manufacture of machinery and equipment n.e.c.	29
electrical engineering		
	manufacture of office machinery and computers	30
	manufacture of electrical machinery and apparatus n.e.c.	31
	manufacture of radio, television and communication equipment and apparatus	32
precision instruments		
	manufacture of medical, precision and optical instruments, watches and clocks	33
automobile		
	manufacturing of transport equipment	34-35
wholesale trade		
	wholesale trade and commission trade (except of motor vehicles and motorcycles)	51
retail trade		
	sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	50
	retail trade (except of motor vehicles and motorcycles), repair of personal and household goods	52
transportation and postal services		
	land transport, transport via pipeline	60
	water transport	61
	air transport	62
	supporting and auxiliary transport activities; activities of travel agencies	63
	post and courier activities	64.1
banks and insurances		
	financial intermediation	65-67
technical services		
	research and development	73
	architectural and engineering activities and related technical consultancy	74.2
	technical testing and analysis	74.3
other business-related services		
	real estate activities	70
	renting of machinery without operator and of personal and household goods	71
	legal, accounting, book keeping and auditing activities; tax consultancy; market research and public opinion pools; business and management consultancy; holdings	74.1
	advertising	74.4
	labour recruitment and provision of personnel	74.5
	investigation and security services	74.6
	industrial cleaning	74.7
	miscellaneous business activities n.e.c.	74.8
	sewage and refuse disposal, sanitation and similar activities	90

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Selbständigkeitserklärung

Ich bezeuge durch meine Unterschrift, dass meine Angaben über die bei der Abfassung meiner Dissertation benutzten Hilfsmittel, über die mir zuteil gewordene Hilfe sowie über frühere Begutachtungen meiner Dissertation in jeder Hinsicht der Wahrheit entsprechen.

Mannheim, den 6. Mai 2011 Jörg Ohnemus