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

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Non-Technical Summary

During past decades, services gained more and more importance as inputs into the production process of firms, not only in service sectors, but also in manufacturing industries. Additionally, firms nowadays increasingly rely on external service vendors (either based locally or abroad) which provide them with the requested services. This paper concentrates on business process outsourcing (BPO), i.e., the contracting of operations and responsibilities of a specific business (service) function (or process) to a third-party service provider. Specifically, the attempt of the paper is to evaluate the impact of business process outsourcing on the outsourcing firms.

The reasons for firms to rely on external service providers are manifold. One main objective is to focus on the core activities. Firms therefore source out all (or at least parts) of their non-core activities which frees management capacity that can be deployed for a further development of the core business. Furthermore, external vendors employ specialised and qualified experts. Outsourcing brings this knowledge into the outsourcing firms. This can result in higher quality services and increased efficiencies. Last, because of economies of scale, external vendors are able to offer their services at lower costs compared to internally provided services. With this consideration in mind, the purpose of this paper is to find out whether or not BPO improves the productivity of the outsourcing firms.

The analytical framework is based upon a Cobb-Douglas production function. For the empirical analysis, a comprehensive panel survey, conducted in the German manufacturing and service industries between 2000 and 2007 by the ZEW, is employed. 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: a pooled OLS estimation, a fixed-effects vector decomposition approach, an Olley and Pakes approach and a System-GMM estimation. The results (over all estimation procedures) clearly show a positive and significant impact of BPO on firm-level productivity. According to the preferred System-GMM estimation results, the engagement in BPO has a positive effect of approximately 9 percent.

Das Wichtigste in Kürze

In den letzten Jahrzehnten haben Dienstleistungen zunehmend an Bedeutung als Vorleistungen im Produktionsprozess von Unternehmen gewonnen. Dies ist nicht nur im Dienstleistungssektor, sondern auch im verarbeitenden Gewerbe zu beobachten. Zusätzlich greifen Unternehmen heutzutage verstärkt auf externe Dienstleistungsanbieter (welche entweder lokal oder im Ausland ansässig sind) zurück, welche den Firmen die benötigten Dienstleistungen zur Verfügung stellen. Diese Arbeit konzentriert sich auf Geschäftsprozessauslagerungen (BPO), d.h. das Auslagern von Tätigkeiten und Verantwortlichkeiten von bestimmten betrieblichen Dienstleistungsfunktionen (oder -prozessen) auf einen Dritten Dienstleistungsanbieter. Im Speziellen wird der Einfluss der Geschäftsprozessauslagerung auf die auslagernden Unternehmen analysiert.

Die Gründe, warum Unternehmen auf externe Dienstleistungsanbieter zurückgreifen, sind vielfältig. Ein Hauptziel, welches durch die Auslagerung oft erreicht werden soll, ist die Fokussierung auf die Kernkompetenzen des Unternehmens. Firmen lagern deshalb alle oder zumindest Teile von nicht zum Kerngeschäft gehörenden Tätigkeiten aus. Dadurch werden zusätzliche Management Kapazitäten freigesetzt, welche nun für die Weiterentwicklung des Kerngeschäfts zur Verfügung stehen. Des Weiteren beschäftigen externe Dienstleistungsanbieter spezialisierte und hochqualifizierte Experten. Durch die Auslagerung wird dieses Wissen auch den auslagernden Firmen zugänglich gemacht, welches dann zu höherwertigen Dienstleistungsprozessen und gesteigerter Effizienz der Prozesse führen kann. Zudem sind externe Anbieter aufgrund von Skaleneffekten in der Lage ihre Leistungen zu geringeren Preisen im Vergleich zur internen Dienstleistungserstellung anzubieten. Ausgehend von diesen Überlegungen wird in dieser Arbeit analysiert, ob die Auslagerung von Geschäftsprozessen die Produktivität der auslagernden Firmen positiv beeinflusst.

Der angewandte Analyserahmen basiert auf einer Cobb-Douglas Produktionsfunktion. Für die empirische Analyse wurde eine umfangreiche Panelbefragung des ZEW aus dem verarbeitenden Gewerbe und dem Dienstleistungssektor in Deutschland aus den Jahren 2000 bis 2007 verwendet. Um für unbeobachtet Heterogenität, Messfehler in den Variablen und

Simultanität zwischen Input und Output zu kontrollieren, wurden verschiedenen Schätzverfahren angewandt: eine *gepoolte OLS* Schätzung, ein *Fixed-Effects Vector Decomposition* Ansatz, ein *Olley und Pakes* Ansatz und eine *System-GMM* Schätzung. Die Ergebnisse (über alle Schätzmethoden hinweg) zeigen einen klaren positiven und signifikanten Einfluss von BPO auf die Unternehmensproduktivität. Gemäße dem Ergebnis der bevorzugten System-GMM Schätzung erhöht die Auslagerung von Geschäftsprozessen die Produktivität um etwa 9 Prozent.

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

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Abstract

This paper analyses the impact of business process outsourcing (BPO) on firm productivity based on a comprehensive German firm-level panel data set covering manufacturing and service industries. The growing importance of service inputs into the production process is undisputed. Firms increasingly buy all or at least parts of selected services they need from external service providers. This is especially true for services which rely to a great extent on new information and communication technologies. Outsourcing firms can concentrate on their core competencies. Additionally, they benefit from the expertise of the external service provider. Finally, external vendors are able to provide services at lower price because of scale effects. By estimating a production function, I show that BPO has a positive and significant impact on firm-level productivity. The results are robust across different estimation techniques.

Keywords: Business Process Outsourcing (BPO), Productivity, Panel Data, Olley-Pakes, System-GMM

JEL-Classification: C23, D24, L24, L60, L80

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1 Introduction

Outsourcing has become increasingly important during the last years and 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 aim of this paper is to analyse the productivity effects of business process outsourcing (BPO), using German firm-level panel data. The overall importance of services as an input into the production process of firms is undisputed. Firms can choose between two different forms of acquiring those inputs: they can produce services themselves or they can subcontract these services to external service providers.[1] Figure 1 reflects the growing importance of external inputs from the *corporate service* sector[2] at the total production value in Germany between 1995 and 2006 (the latest point in time for which information from input-output tables is available from the German Statistical Office). The share of those intermediate inputs rose from 6.07 percent in 1995 to 7.33 percent in 2006 which accumulates in a total increase of almost 21 percent. Although the increase in percentage point terms seems rather moderate, the absolute numbers are quite substantial. For 1995, the absolute sum of inputs from the corporate service sector amounted to 196 billion Euros and until 2006, this value rose to about 325 billion Euros.[3] The share of imports is represented by the distance between the straight and the dashed line in Figure 1. As can be easily verified, this share is only small but has been continuously rising during the last years.[4] To shed some more light on this figures, I divided the total economy into manufacturing and service industries. The results are presented in Figure 2 and 3. The

[1] Sometimes, firms, especially larger ones and those with several subsidiaries, found their own service division which then provides services to all the other parts of the group. Sometimes those service divisions also begin to offer their service 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). Of course this is a very broad definition if one is focussing on business process outsourcing. Eurostat, for example counts to 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.

[3] Note that these are nominal values and therefore are not deflated.

[4] In 2006, the share of imports from the corporate service sector amounted to 26 billion Euros or 7.8 percent of the total inputs from this sector.

increase in manufacturing is not as pronounced compared to the service industry. Whereas in the first one, the share of intermediate inputs from the corporate service sector rose by about 9 percent, the later one shows an increase between 1995 and 2006 of more than 22 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 industry, the share of imports (indicated as the difference between the straight line and the dashed line) is substantially higher.

In the same time period, the share of value added in the corporate service sector of total value added in Germany rose from 9.0 percent almost continuously to 11.7 percent as displayed in Figure 4. This amounts to an increase of almost 30 percent. Correspondingly, also the share of employees working in the corporate service sector grew significantly. In 1995, the corporate service sector accounted for a share of 7.4 percent of total employment. This share rose by 66 percent to 12.3 percent until 2006. Altogether, this information points to a simultaneous growth of the corporate service sector as demand for the services provided by this sector from the rest of the economy (as shown above) increased. This growth is required, since only a small fraction of corporate services is imported.

The above mentioned figures illustrate the growing importance of external service provision for the German economy. However, why should firms resort to external providers and give away decision power and (maybe) flexibility? The reasons for firms to rely on external service providers are manifold. One central argument often given by firms for their involvement in outsourcing of services is their wish to focus on their core activities. In a representative survey conducted by the Centre of European Economic Research (ZEW), more than 82 percent of the outsourcing firms mention this argument as the main driver for subcontracting business processes.[5] They therefore source out all (or at least parts) of their non-core activities (Gilley and Rasheed, 2000; Merino and Rodríguez Rodríguez, 2007). The purpose of this paper is to find out whether firms outsourcing business processes achieve advantages in terms of productivity increases. Employing external service vendors for their non-core processes may allow firms to spend more time dealing with their

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

'real' business. A Cobb-Douglas production function is used as analytical framework. For the empirical analysis, a comprehensive panel survey conducted in the German manufacturing and service industries between 2000 and 2007 by the ZEW is employed. 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). 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 remainder of the paper is structured as follows: Section 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 introduces the estimation procedures. In Section 4, the dataset and the applied transformation steps are presented. Section 5 discusses the estimation results and makes some robustness checks. Section 6 concludes.

2 Background Information

Business process outsourcing is a broad term referring to subcontracting in all fields of economic activity of the firm. 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.* According to this definition, there are three main characteristics distinguishing 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 outsourcer. This means that the outsourcing provider not only takes over administrative responsibility for a technical function, but also assumes strategic responsibility for the execution of a complete, *business-critical* function. This additional step can introduce new efficiencies and cost savings for the outsourcing firm, 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 not categorised as BPO. Last, the service provider is actively involved in the long term strategic and operational success of the outsourcing firm. Typically, BPO comprises services from the area of finance and accounting, human resource management, procurement, logistic, customer care, programming and IT-infrastructure. Since all those services rely heavily on information and communication technology, BPO is sometimes also categorised as an information technology enabled service (ITES).

An important fact of business process outsourcing is its ability to free corporate executives from some of their day-to-day process management responsibilities, which is taken over by the service provider for the outsourced services. Executives usually spend most of their time managing everyday business and only some time on formulating strategies for a successful advancement of the company. This may look quite different when certain business processes are outsourced. Once a process is successfully outsourced, the time spending ratio can be easily reversed and more time is left to explore new revenue areas, accelerate other projects and focus on customers, i.e. to concentrate on the core competencies of the firm. This may improve efficiency and firm productivity. Additionally, outsourced services are carried out by highly specialised and qualified experts in the vendor company. Those experts bring with them increased productivity and years of experience that the vast majority of outsourcing firms previously did not have access to or could not afford on their own. This leads to qualitatively better services and a faster adoption of well-defined business processes. A last important point in favour of BPO is the cost advantage associated to service outsourcing. As already mentioned, BPO vendors are highly specialised on the service product they offer. Usually, some parts of a outsourced business service are standard for a vast majority of the BPO providers' customers. This implies economies of scale and results in lower cost (compared to in-house production of the outsourcer) at least in the long run, when the cost for search and contracting and initial coordination problems are incorporated.

As already stated above, BPO is sometimes also categorised as an *information technology enabled service*. The undoubtable increasing importance of information and communication technologies (ICT), especially the usage of computers and intra and internet network connections, has also revolutionised the provision of services. Even more important, a broad variety of new services has been developed because of the possibilities offered by new and fast developing ICTs. Therefore, the vast majority of business processes today rely in some way on information and communication technologies. In addition, the operation of a firm's ICT infrastructure itself can be interpreted as a business process.

Various authors have analysed the determinants of ICT/IT outsourcing and offshoring, for instance Loh and Venkatraman (1992) as well as Barthélemy and Geyer (2001; 2004; 2005). Further research was devoted to the outsourcing firms' performance, basically trying to identify (labour) productivity effects of IT outsourcing. Maliranta et al. (2008) thereby find out 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 finds the opposite. He shows that IT outsourcing firms are more efficient in their production processes. Furthermore, he finds that employees working at a computerised workplace are more productive in IT outsourcing firms. Besides the empirical literature dealing with IT outsourcing, there is also a variety of theoretical papers, for a comprehensive overview see Dibbern et al. (2004).[6]

[6] In their literature overview, Dibbern et al. (2004) analyse 84 papers published between 1992 and 2000. They find that most of the studies focus on Transaction Cost Theory, Agency Theory or Strategic Management Theory as a reference framework to explain IT outsourcing.

Regarding the determinants of service outsourcing, Abraham and Taylor (1993) constitute the beginning of this strand of empirical literature.[7] They find that 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 plays also 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

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

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.

The literature with a specific BPO focus is still scarce, although in recent years, efforts are made to cover this topic more thoroughly. Willcocks et al. (2004), for example, stress the knowledge potential inherit in (IT-intensive) business process outsourcing, which is the premise for the dramatic growth of BPO since 2001. Indeed, also the data I use in this paper show a high increase in BPO starting in the year 2000, as stated in Figure 6. The paper 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 s 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. As R&D is somehow special in the list of potential business processes, 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.[8]

As empirical evidence on the link between business process outsourcing and productivity is limited, and hence a reason to conduct the analysis in this paper to fill the gap, I will concentrate in the following on the much broader service outsourcing literature. Moreover, a vast majority of authors is concentrating on service offshoring (outsourcing to a service provider abroad), driven by the cost advantage argument associated with offshoring to low wage countries (like India or eastern European countries).

While most of the empirical literature analysing the relationship between outsourcing (and especially offshoring) and performance is focussing 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 US-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 US-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 loose of highly qualified employees in industrialised countries, service offshoring in the US 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 US-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

[8] 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).

[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. (2006, forthcoming in *Economic Inquiry*, 2010), Jabbour (2007, forthcoming in *The World Economy*, 2010), Broedner et al. (2009) and Wagner (2009).

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

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 apply also 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 literature on the effects of business process outsourcing and productivity is still missing. By conducting the following analysis, I try to close this gap.

3 Analytical Framework

In order to investigate the impact of business process outsourcing on output at the firm-level, I refer to a Cobb-Douglas production function framework:

$$\begin{aligned} Y_{it} &= F(A_{it}, L_{it}, K_{it}, BPO_{it}) \\ &= A_{it}\ L_{it}^{\alpha}\ K_{it}^{\beta}\ \mathrm{e}^{\gamma BPO_{it}}, \end{aligned} \tag{1}$$

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 if 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}:

$$\ln(A_{it}) = c \;+\; \eta_i \;+\; \lambda_{j(i),t} \;+\; \epsilon_{it}. \tag{2}$$

After taking logarithms on both sides of Equation 1 and inserting Equation 2, one can rewrite the empirical model in the following way:

$$y_{it} \;=\; c \;+\; \alpha\, l_{it} \;+\; \beta\, k_{it} \;+\; \gamma\, BPO_{it} \;+\; \eta_i \;+\; \lambda_{j(i),t} \;+\; \epsilon_{it}, \tag{3}$$

where small 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 management (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. 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

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

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 change only rarely over time. For the analysis conducted in this paper, 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 problem, 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 estimation 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 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. The prediction power of the

[12] The simultaneity problem in a production function framework arises when contemporaneous correlation between the input factors and the error term exists. 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 7 and 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.

internal instruments could be small, however, 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 of 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).

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 were 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

[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.

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]

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 dataset 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 more to intermediate goods 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 apprentice.[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

[17] For a further discussion of this point, see page 15.

[18] For these calculations I used Table 81000-0103 and Table 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.

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 am assuming that firms that report an investment value of zero have at least little investments undertaken but this value is low and is 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:

$$K_{it} \quad = \quad (1 - \delta_{j(i)})K_{i,t-1} \; + \; I_{it} \tag{4}$$

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

[21] For the restricted sample (see page 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).

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 extend 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 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 5 gives an overview how intensively German firms (with five and more employees) outsource these processes, divided into manufacturing and service industries.

For the empirical analysis, two datasets are generated referred to in the following 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 paper and BPO information was only collected in the 2007 wave, all firms included in the (full and restricted) sample must

[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 4 can be rewritten for period $t = 1$ (1999) by backward substitution in the following way: $K_1 = I_1 + (1-\delta)I_{-1} + (1-\delta)^2 I_{-2} + \ldots = \sum_{s=0}^{\infty} I_{-s}(1-\delta)^s = I_0 \sum_{s=0}^{\infty} [(1-\delta)/(1+g)]^s = I_1/(g+\delta)$. 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.

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 Table 7 and Table 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 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 1. Average value added per employee is 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.

[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.

[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 (measured in prices of 1995). For 2006 no value is yet available.

Table 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 is 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 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 biggest group of observations in the restricted sample stems from the *metal and machine construction industry* with 13.4 percent as indicated by Table 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 presents the distribution of outsourcing and non-outsourcing firms by industry and year of observation. Taking a look at Figure 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 1990th, 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 from 1999 to 2006 of 18.9 percentage points. 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 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

[27] For a detailed description and composition of the sectors included in the survey, see Table 10.

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

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 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 as 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 outsource at all. If the mean value and especially the distribution 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) are revealed by applying the non-parametric Kolmogorov-Smirnov test. Results are presented in Table 5. 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 5 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

[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 productivity effects from BPO are actually incorporated due to initial starting problems and adjustment efforts which have to be made.

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

5 Empirical Results

This section presents the estimation results achieved by using different (panel) estimation techniques already mentioned in Section 3 to end up with a reliable and consistent estimate of the impact associated to business process outsourcing on productivity.

In Table 6, 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

[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.

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

The third and fourth column of Table 6 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 and the computer employment share also show a reduced magnitude, but with 0.431 and 0.509 (in the specification with BPO), those lie in 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 6.[33] Comparing the coefficients for capital and labour with the results achieved by pooled OLS, we see a

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

[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).

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. 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.[34] 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 to be exogenous. System-GMM estimation results are presented in the last two columns of Table 6, 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

[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.

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 in Section 4.[37] Summary statistics for the full sample are shown in Table 7 and the estimation results are reported in Table 8. 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.

[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.

[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.

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 9 presents the results thereof, where only the BPO coefficients are reported. None of the regressions shows 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.

6 Concluding Remarks

The existing empirical literature concerning the relationship between business process outsourcing and productivity is very scarce. Even more, the literature on the much broader field of service outsourcing gives a diverse picture concerning the performance effects of outsourcing. The aim of this paper 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 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 finally 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 rather captures the 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.

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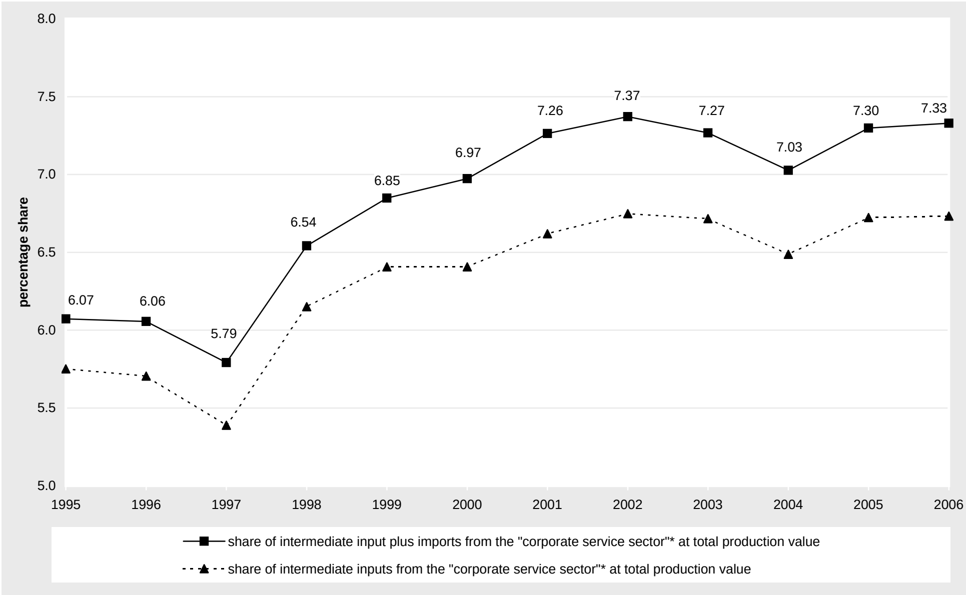
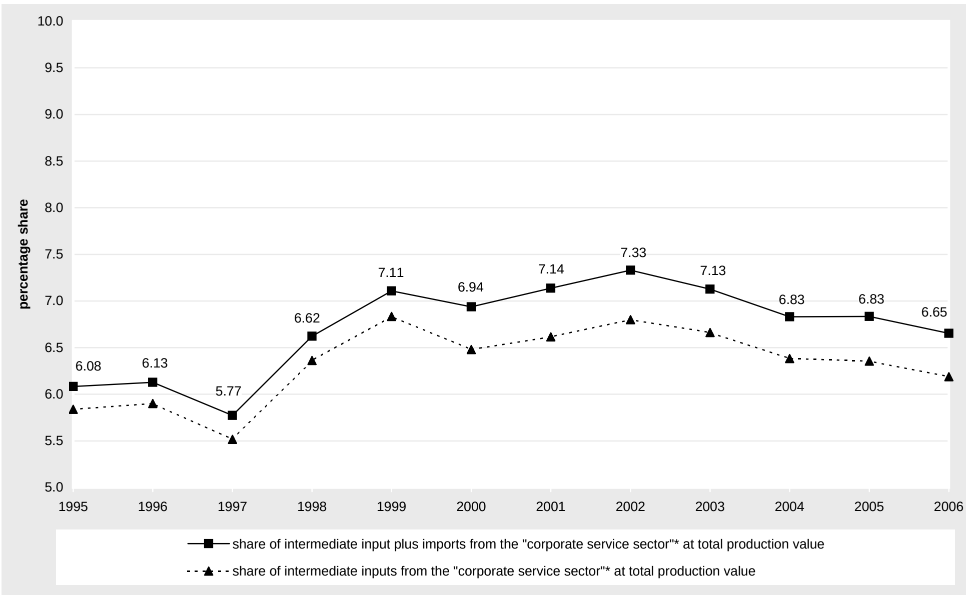
Appendix

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



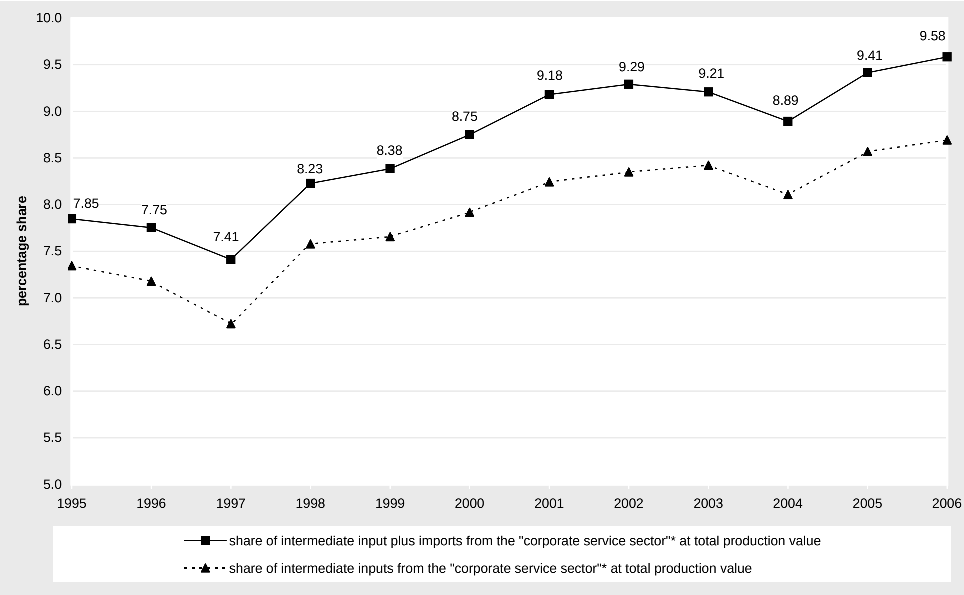
Note: *The "corporate service sector" comprises the sectors "computer and related activities" (NACE 72), "research and development" (NACE 73) and "other business activities" (NACE 74).
Source: Based on input-output tables provided by the Germany Statistical Office and authors' calculations.

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



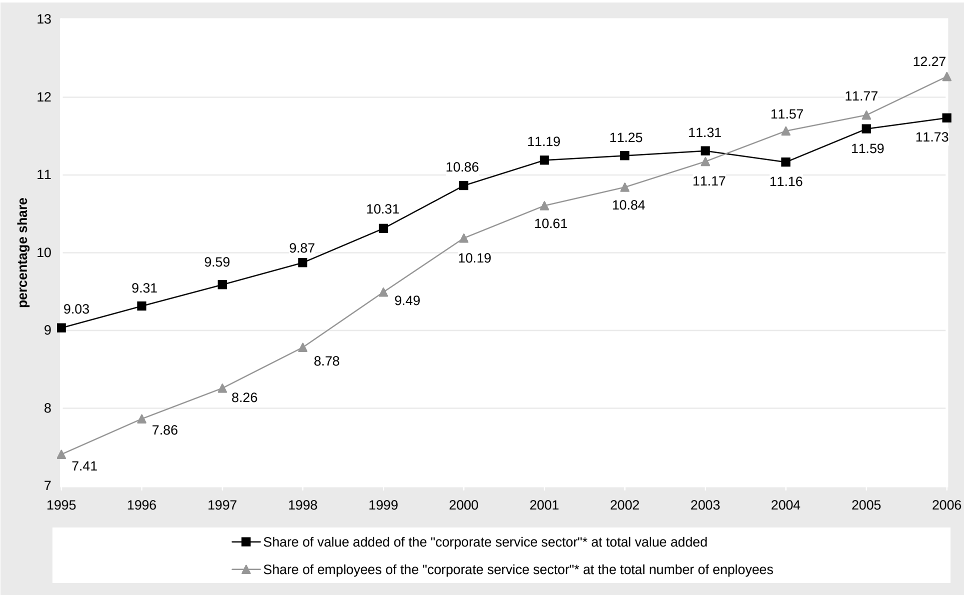
Note: *The "corporate service sector" comprises the sectors "computer and related activities" (NACE 72), "research and development" (NACE 73) and "other business activities" (NACE 74).
Source: Based on input-output tables provided by the Germany Statistical Office and authors' calculations.

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



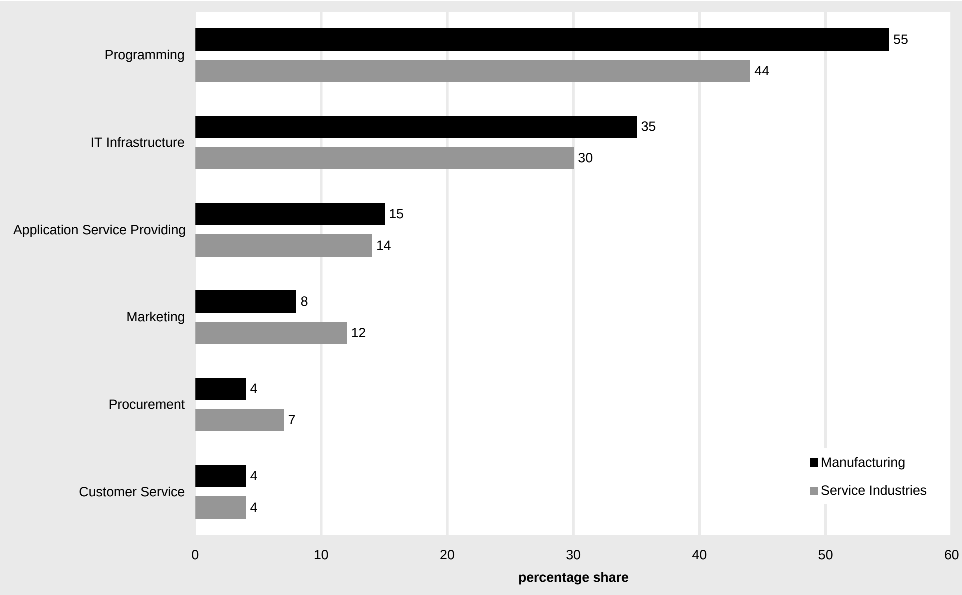
Note: *The "corporate service sector" comprises the sectors "computer and related activities" (NACE 72), "research and development" (NACE 73) and "other business activities" (NACE 74).
Source: Based on input-output tables provided by the Germany Statistical Office and authors' calculations.

Figure 4: Share of value added (employees) in the "corporate service sector"* of total value added (employees) in 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 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.

Figure 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.

Table 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 emp.	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 p. emp.	75.58	49.18	93.24	50.81	101.60	54.82	124.34	63.33
capital p. 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.

Table 2: Descriptive statistics (restricted sample) – BPO vs 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	

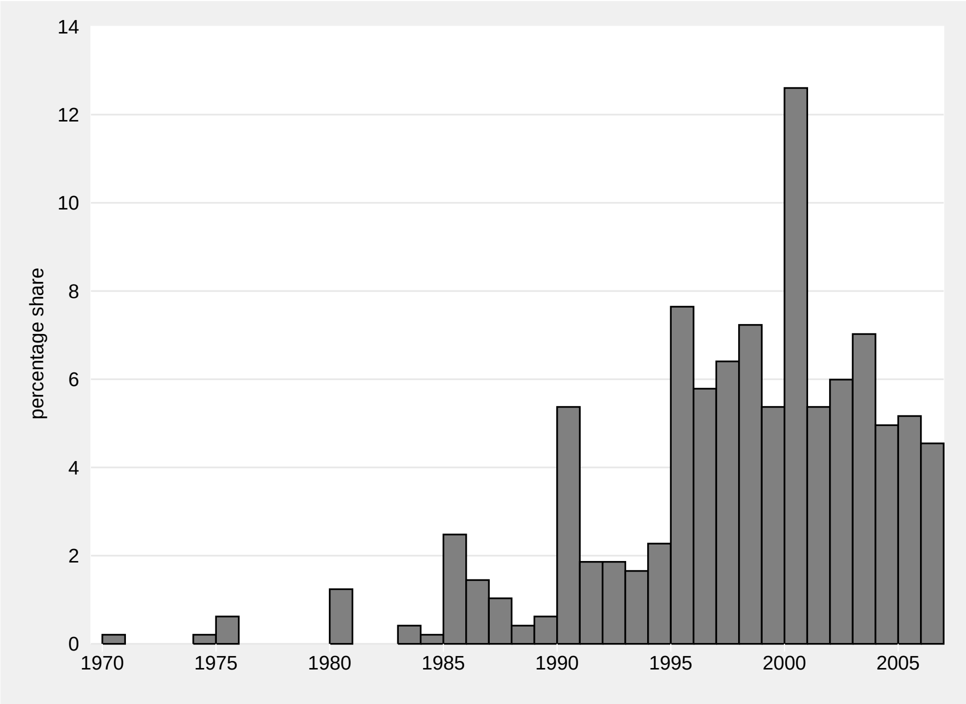
Note: Monetary values are in 1 000 Euros in prices of 2000.
Source: ZEW ICT-survey.

Table 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.

Figure 6: Starting year of business process outsourcing



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

Table 4: Comparison of mean log labour productivity (value added per employee) of BPO and non-BPO firms

			Quantile			
	Mean	**Std.Dev.**	**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 $\neq 0 \rightarrow [\ p > |t|\ ] = 0.1425$

H_0: mean(w/ BPO, 2001) - mean(w/o BPO, 2001) = diff = 0 $\rightarrow t = 3.4247$
H_1: diff $\neq 0 \rightarrow [\ p > |t|\ ] = 0.0007$

H_0: mean(w/ BPO, 2003) - mean(w/o BPO, 2003) = diff = 0 $\rightarrow t = 4.4980$
H_1: diff $\neq 0 \rightarrow [\ p > |t|\ ] = 0.0000$

H_0: mean(w/ BPO, 2006) - mean(w/o BPO, 2006) = diff = 0 $\rightarrow t = 3.7471$
H_1: diff $\neq 0 \rightarrow [\ p > |t|\ ] = 0.0002$

Note: Labour productivity is value added per employee in 1 000 Euro in prices of 2000.
Source: ZEW ICT-survey.

Table 5: Ex-ante comparison of log labour productivity (value added per employee) of BPO and non-BPO firms

	Mean with BPO	**Mean without BPO**	***t*-test (*p*-value)**	**Kolmogorov-Smirnov 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.

Table 6: 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.

Table 7: 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 emp.	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 p. emp.	188.96	51.29	104.70	52.50	107.71	54.09	119.84	57.89
capital p. 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.

Table 8: 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 empl.	0.6580***	0.6435***	0.6361***	0.5427***	0.6417***	0.6286***
	(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 9: Estimation results (restricted sample)

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

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 6, column 8.
Source: ZEW ICT-survey and own calculations.

Table 10: 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