External technology supply and client-side innovation

Christian Peukert*

Institute for Strategy, Technology and Organization

Ludwig-Maximilians-Universität München, Germany

March 1, 2011

Abstract

The market for IT outsourcing has extensively grown during the last decade. At the same time the aim of external IT provision has transformed from cost-cutting to following strategic goals. For related types of business services, the literature has identified a potential to build bridges for innovation.

We employ a stylized theoretical model to derive hypotheses for the empirical analysis of the role of IT outsourcing in product and process innovation.

Estimation results based on German firm-level data suggest that IT outsourcing has positive effects on both types of innovation. For product innovation we find a hump-shape.

Keywords: Outsourcing, IT, KIBS, innovation, ZEW ICT survey

JEL No.: O31, L24, D23, D83

*Preliminary version. I would like to thank Centre for European Economic Research, Mannheim, Germany (ZEW) for providing access to the data during my visits in 2009 and 2010. An earlier draft of this paper entitled "IT Outsourcing and Innovation - Getting more by doing less?" was presented at the 4th International Conference on Industrial Dynamics, Innovation Policy and Growth (TED), Izmir, Turkey, May 2010 and the 12th European Network on Industrial Policy (EUNIP) International Conference, Reus, Spain, June 2010. I am grateful to Werner Smolny, Daniel Cerquera and Daniel Siepe for very helpful comments. All errors are mine. Contact information: christian.peukert@gmail.com.

1 Introduction

Make-or-buy decisions have a long history. For example, already in the ancient Roman Empire tax collection was given in private hands (Kakabadse and Kakabadse, 2002, p. 189). Hence, long before the Industrial Revolution, division of labor has been identified as source of efficiency enhancement. The relevance of outsourcing has not only increased over time, but recently also more knowledge-intensive corporate functions are subject to make-or-buy decisions. In the twentieth century, flexibility in response to globalized markets and increasingly individualized customer desires has gained much importance. At this, cooperation in research and development (R&D) and external provision of information technology (IT) attracts more and more attention. Ever since Eastman Kodak decided to hand over its entire data center to IBM in 1989 (Loh and Venkatraman, 1992, p. 8), the market for IT outsourcing has extensively grown in all parts of the world (Lacity and Willcocks, 2001, p. 2 sq.). In Germany for example, 66 percent of firms with at least 10 employees have been sourcing out IT activities in 2007. Only Finland and Denmark have a higher percentage share in the EU15 countries (Eurostat data, see Figure A.1). While in the beginning firms focused on cost reductions, in recent years, IT outsourcing has been increasingly identified as a strategic tool to focus on core competencies and improve the quality of internal IT systems. Despite its growing practical relevance, the academic literature provides mixed evidence on the outcome of IT outsourcing. Rouse (2009) and Windrum et al. (2009) conclude their reviews of the literature with the claim of an 'information technology outsourcing paradox': In the short-run, IT outsourcing exhibits positive impacts on productivity (Ohnemus, 2007; Maliranta et al., 2008; Knittel and Stango, 2008). However, client organizations often report to be dissatisfied with the work of the vendor in the long run. Rouse (2009) argues that this is due to myopic management (omission of hidden costs) and opportunistic vendor behavior.[1] As the literature has identified innovation as source of labor productivity enhancement and growth (see for example Smolny, 2000), this paper tries to empirically answer the following question. Can IT outsourcing impact the client firms' innovative capabilities?

[1] "Perhaps its time for vendors to 'come clean' by acknowledging that making outsourcing work effectively is probably much harder, and more expensive, than most purchasers expect." (Rouse, 2009, p. 144)

Beside some case study evidence (Kumar and Snavely, 2004; Miozzo and Grimshaw, 2005; Feeny et al., 2006; Weeks and Feeny, 2008), to the best of our knowledge, this is the first paper to empirically investigate a relationship between IT outsourcing and different types of innovation.[2]

We employ a stylized theoretical model to derive hypotheses for the empirical analysis of the role of IT outsourcing in product and process innovation. Estimation results based on German firm-level collected by Centre for European Economic Research (ZEW Mannheim) suggest that IT outsourcing has positive effects on both types of innovation. For product innovation we find a hump-shape.

This study may mainly contribute to the recent literature on innovation and outsourcing (for example Hoecht and Trott, 2006; Weeks and Feeny, 2008; Lai et al., 2009; Jayatilaka, 2009; Windrum et al., 2009), however, it also ties up to the literature on innovation and knowledge intensive business services (KIBS) (Bessant and Rush, 1995; Antonelli, 1998; Muller and Zenker, 2001; Czarnitzki and Spielkamp, 2003; Howells, 2006).

The remainder is structured the following. First, we present a stylized theoretical model of outsourcing and innovation. We describe data and methodology in the next sections, followed by a discussion of our results. Finally, we conclude and give some directions for further research.

2 A stylized model of innovation and outsourcing

A significant amount of articles in the trade press (e.g. Overby, 2007, 2010; Bacheldor, 2010) report that clients are dissatisfied with the innovativeness of vendors. Only 24% of 290 respondents to an online survey of subscribers to the CIO magazine (print and online) indicate that outsourced activities contributed most to IT innovation (compared to 76% in-house). According to Overby (2010) the clients are to blame. Innovation is expected but often not properly defined, and sometimes not recognized because traditional business metrics fail to properly measure innovation outcomes. However, scientific empirical

[2] Note that there are related papers by Görg and Hanley (2009) and Weigelt and Sarkar (2009) in which the authors study the link between international (service) outsourcing and innovative activity, and the effects of a vendor's experiential diversity on client's innovation adoption, respectively.

research on innovation and IT outsourcing is scarce.[3]

In a recent article Windrum et al. (2009) present a model of organizational innovation in which a firm's decision on internally or externally sourcing an activity has different effects on short run and long run productivity growth. Organizational innovation or organizational change is to be seen as a cycle that starts with process improvements to increase efficiency, goes on with process innovations that increase quality and finally stimulates the development of new products and services (Barras, 1986). Windrum et al. posit that modern information technologies radically expand technical opportunities for the outsourcing of production, and significantly lower external coordination costs. A short run consequence of outsourcing is a reduction in the depth of hierarchy. This results in a short run reduction of fixed cost and gains in productivity. Accordingly, this increases the probability that the firm will choose the outsourcing option again; the firm becomes locked-in to an outsourcing trajetory. Hence it is managerial control that matters, not ownership per se. This conclusion is very similar to Rouse's (2009) review of case studies, where she argues that the outsourcing paradox is due to myopic management (omission of hidden costs) and opportunistic vendor behavior.

2.1 Knowledge

In this paper, we take the knowledge perspective and explore different types of outsourcing arrangements by looking through the lens of transaction cost economics (Williamson, 1975, 1985, 1991). The information systems literature finds that outsourcing is no "simple dichotomous decision" (Grover et al., 1996, p. 95) and thus suggests to distinguish between different types of sourcing decisions, for example complete ('total') and partial ('selective') IT outsourcing (Lacity and Willcocks, 2009). Following Williamson (1991), we compare different types of organization $\omega \in \{H, X, M\}$, in-house ('hierarchy'), partial outsourcing ('hybrid') and complete outsourcing ('market'). From the knowledge perspective, organizations may be characterized as "social communities in which individual and social expertise is transformed into economically useful products and services by the application of a set of higher-order organizing principles"(Kogut and Zander, 1992, p. 384). That is,

[3] See Windrum et al. (2009) for an extensive review of empirical studies on productivity and (IT) outsourcing, Corrocher et al. (2009) and Bengtsson and Dabhilkar (2009).

a firm's capability to innovate arises from exploring and exploiting internal and external competencies in response to economic conditions. Hence, choosing the optimal sourcing strategy involves to understand IT outsourcing not only "as the product of a decision process, but, more fundamentally, as a particular way of organizing knowledge"(Scarbrough, 1998, p. 137). Consider this process of gathering and sharing tacit experience, and articulating and codifying it into explicit knowledge (Shi, 2007, p. 37; Nonaka and Takeuchi, 1995) to be specified as a knowledge production function (Griliches, 1979), such that

$$\dot{A}(\kappa) = A(\kappa) + R(K) - c_\omega(\kappa)K, \tag{1}$$

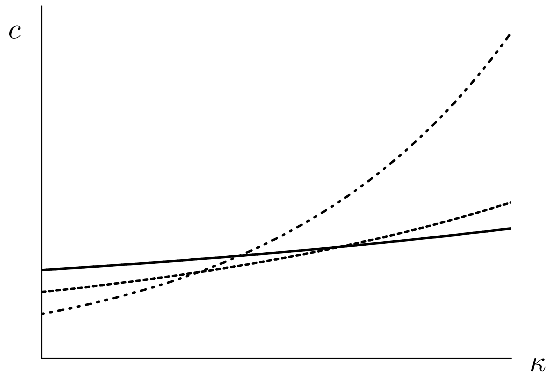
where knowledge inputs K can be provided internally, as well as by sources external to the firm, and $R(K)$ gives returns to knowledge. It is assumed that returns increase with knowledge, such that $\frac{\partial R}{\partial K} > 0$. The literature has found that knowledge-intensive business services (KIBS) in general act as a "mediator" (Antonelli, 1998, p.178) and "systems integrator" (Bessant and Rush, 1995, p. 98) by transferring knowledge to their customers, directly or indirectly embodied in the supplied service (Czarnitzki and Spielkamp, 2003). Expertise accumulated from the combination of explicit knowledge, client's knowledge and their own tacit knowledge allows KIBS to produce solutions to individual problems (Antonelli, 1998). Therefore, KIBS are like "bees cross-pollinating between firms, carrying experiences and ideas from one location or context into another" (Bessant and Rush, 1995, p. 102), complementing their client's internal absorptive capacity (Muller and Zenker, 2001).

2.2 Transaction costs

Further, according to transaction cost economics, bounded rationality and opportunism raise issues that lead to heterogenous transaction costs c_ω among different types of organization.[4] The literature has shown that IT requires complementary innovations in order to become productive; for example an implementation that facilitates the interconnection of corporate structures (Brynjolfsson and Hitt, 1995). When IT is fully handled over to an

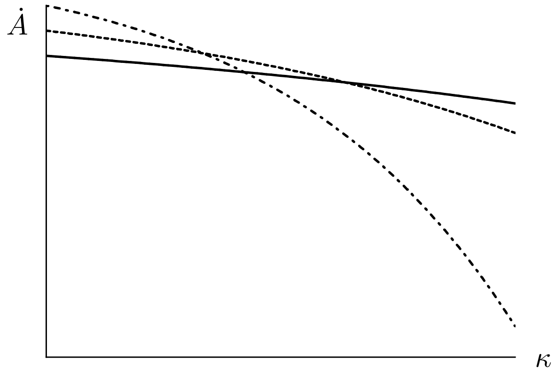
[4]Williamson (1991) considers governance costs consisting of production costs and transaction costs. For simplicity we assume unit production costs.

Figure 1: Transaction costs



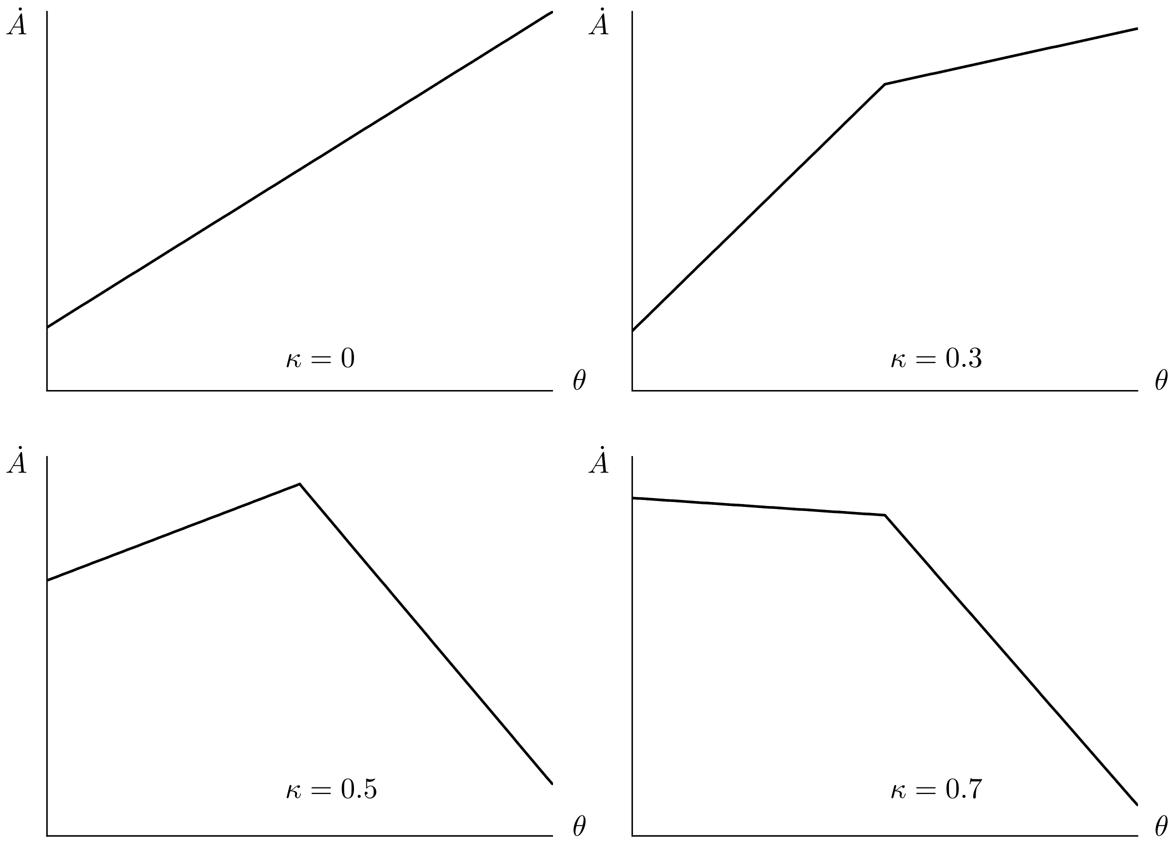
— *Hierarchy* --- *Hybrid* -·· *Market*
Similar to Williamson (1991), Figure 1, p. 284.

Figure 2: Knowledge growth



— *Hierarchy* --- *Hybrid* -·· *Market*

Figure 3: Knowledge growth as a function of the outsourcing level



Knowledge growth $\dot{A}$ as a function the outsourcing level θ, holding asset specificity κ fixed.

external vendor, specific technological knowledge, but also firm-specific knowledge on the interconnectedness of IT and business processes (Lacity et al., 2009, p. 216) left the company with the staff that has been laid off or transferred to the supplier.[5] Further, switching to alternative technologies and modes of provision is costly (Lacity and Hirschheim, 1995, p. 221; Lacity et al., 2009, p. 217 sq.; Peukert, 2011). This imposes dependency on the innovative strength of the vendor. For the vendor, the presence of switching costs implies future monopoly power. Thus, in expectation of market share, prices (qualities) in early periods are lower (higher) than those in later periods (Farrell and Klemperer, 2007). Finally, economies of scale provide incentives to implement standardized solutions. Clients receive less customized and hence relatively less useful services (with respect to knowledge transfer).[6] That is, transaction costs are driven by bilateral dependency (asset specificity κ), i.e. the need for coordinated investments and coordinated realignment (Williamson, 1991). In case of market organization, those coordination costs are rather inelastic with respect to specificity, while coordination costs in a hierarchical organization are more elastic with respect of specificity. On the other hand, the bureaucratic costs of a hierarchical organization exceed those of a market organization even if asset specificity is negligible. Figure 1 illustrates the assumptions of $c_M(0) < c_X(0) < c_H(0)$ and $\frac{\partial c_M}{\partial \kappa} > \frac{\partial c_X}{\partial \kappa} > \frac{\partial c_H}{\partial \kappa} > 0$. From the graphical representation of equation (1) in figure 2 it becomes evident that market organization is optimal for assets with low specificity.[7] For semi-specific assets, a hybrid mode of organization is optimal, and in case of high specificity the highest growth rate of knowledge is achieved in a hierarchical organization.

This becomes more clear-cut when we plot knowledge growth as function of the outsourcing level θ in figure 3; hierarchy corresponds to $\theta = 0$, hybrid corresponds to $\theta = 0.5$, and market corresponds to $\theta = 1$. Dependent on the level of specificity, the model suggests different functional forms for the relation between knowledge production and the level of outsourcing. For low levels of specificity the results point to an increasing relation (upper panel of figure 3). For medium levels the model suggests a hump-shape and for high levels of specificity the model predicts a decreasing relation.

[5] For example, when Deutsche Bank signed its contract for data center operations with IBM, 900 employees moved over to IBM (Dibbern and Heinzl, 2006, p. 58).

[6] Compare Miozzo and Grimshaw (2005) and Feeny et al. (2006), who claim a "Lack of Fit between homogenous provider solutions and heterogeneous client contexts" (Feeny et al., 2006, p. 545).

[7] For simplicity we set $A(\kappa) = 0$, and $R(K) = K = 1$, such that $\dot{A}(\kappa) = 1 - c_\omega(\kappa)\ \forall \omega \in \{H, X, M\}$.

2.3 Innovation

We finally model the process of innovation as the probability that an increase in knowledge, measured as a growth rate $\dot{A}$, exceeds a certain threshold level τ. Economically this may be interpreted as the net value of an invention. If the invention is promising enough, i.e. the expected profits after considering implementation costs are positive, the firm starts the implementation/places it on the market. Hence, the probability to innovate is given by

$$\text{Prob(Inno)} = \text{Prob}(\dot{A} > \tau) = 1 - \text{Prob}(\dot{A} \leq \tau) = 1 - \int_{-\infty}^{\tau} f(y)dy \quad \forall \tau \in \mathbb{R} \tag{2}$$

where $f : \mathbb{R} \rightarrow [0, \infty)$ is the p.d.f. of $\dot{A}$.

3 Data

The empirical analysis is based on the *ZEW ICT Survey*, a telephone survey conducted with a special focus on diffusion and use of information and communication technology (ICT) in German companies. Stratified on a sectoral, size class and locational basis, more than 4,000 firms are interviewed on a broad range of questions. While the data offer information on the use of ICT in the firm, we also observe variables on innovation, personnel and human capital, export, industry affiliation and location. To incorporate a time-lag needed for innovation to be created and successfully launched, and to cover the potential issue of reverse causality, data from two waves is used. Innovation variables are employed from the 2007 data and refer to the time span of 2004 to 2006. Variables on IT outsourcing and controls are taken from the 2004 data and refer to 2003. Due to item-nonresponse and panel attrition the sample size is 1582 observations.

The data allow to distinguish between product innovation and process innovation, where both are defined to be *new or markedly improved.* The majority of firms in the sample has been innovating during 2004 to 2006. About 59 percent report to have launched new products and services, while roughly 66 percent report to have introduced improved or new processes. Correspondingly, about one quarter has done both product and process innovation.

Firms are asked whether they are using specific types of IT services j and indicate the mode of provision: inhouse, partial outsourcing or complete outsourcing.[8] That is, S_i^j is defined as

$$S_i^j = \begin{cases} 0, & \text{not in use} \\ 1, & \text{inhouse} \\ 2, & \text{outsourced partially} \\ 3, & \text{outsourced completely.} \end{cases} \tag{3}$$

From this information we construct a firm-specific measure for the outsourcing ratio, defined as the proportion of outsourced IT on total IT,

$$\tilde{\theta}_{i,\gamma} = \frac{\gamma \overbrace{\sum_{j=1}^{J} I(S_i^j = 2)}^{P_i} + \overbrace{\sum_{j=1}^{J} I(S_i^j = 3)}^{C_i}}{\underbrace{\sum_{j=1}^{J} I(S_i^j > 0)}_{T_i}}, \tag{4}$$

where $I(\cdot)$ is the indicator function. Because we do not know if 'partial' is 10% outsourcing or 90% outsourcing, we assume a weight of $\gamma \in (0,1)$. The major weakness is yet something different. Consider the following example. Firm a has only one IT service in use ($T_a = 1$), firm b uses the whole range of IT services ($T_b = J$), both are complete outsourcers ($P_a = P_b = 0, C_a = 1, C_b = J$). While those firms are clearly different, both exhibit the same outsourcing ratio $\tilde{\theta}_{i,\gamma} = 1$. In order to consider the firm-specific importance of IT in our measure of outsourcing, we weight $\tilde{\theta}_{i,\gamma}$ with a measure of IT intensity η_i, such that

$$\theta_{i,\gamma} = \eta_i \cdot \tilde{\theta}_{i,\gamma} \in [0,1]. \tag{5}$$

[8] Those IT services are installation of new hard- and software, system support and maintenance, support help desk, software development, internet/web maintenance and design, IT training, IT security and on-demand-computing.

We operationalize η_i with the percentage of computerized workplaces.[9] In the following we use the term *outsourcing ratio* for $\tilde{\theta}_{i,\gamma}$ and the term *outsourcing level* for $\theta_{i,\gamma}$.

4 Empirical specification

We estimate two differently specified sets of probit models for product and process innovation and $\gamma \in \{0.1, 0.2, \ldots, 0.9\}$, where the first is given as

$$inno_{i,\gamma} = f(\alpha + \beta\theta_{i,\gamma} + \delta' x_i + \varepsilon_i) \qquad \text{(specification A)}$$

where α, β, δ are coefficients and ε_i is an error term. To test the predictions of our stylized theoretical model, we also estimate a quadratic specification, i.e.

$$inno_{i,\gamma} = f(\alpha + \beta_1\theta_{i,\gamma} + \beta_2\theta_{i,\gamma}^2 + \delta' x_i + \varepsilon_i). \qquad \text{(specification B)}$$

We include a small and standard set of covariates in the vector x_i:

Log employees: As a measure of firm size, the model includes the logarithm of the number of employees working for the firm in Germany on an average in 2003 – including apprentices and part-time employees and excluding secondary labor force.[10]

% University, Job training: Technological competence is strongly related to the innovative capabilities of personnel. We control for two types of human capital, formal human capital, i.e. the proportion of staff with university degrees, and firm-specific human capital, i.e. a dummy for job training.

Business situation: The demand-pull-view assumes that customer involvement has an indirect impact on firm innovation through "patterns of demand" (Dosi, 1982, p. 149). However, according to the arguments summarized by Geroski and Walters (1995), this mechanism could work pro- or anti-cyclical. In the survey, interviewees are asked to express a sentiment on their current business situation. From very good to very bad, four answers are possible. A dummy variable is constructed to be equal to zero if sentiments are given as rather bad and very bad, equal to one if rather good and very good.

[9] Descriptive statistics on IT intensity can be found in table 1.

[10] Cohen (1995) summarizes key issues in the empirical literature in favor of a firm size effect on innovation.

Export: The (spatial) openness of a firm, i.e. access to remote markets, acts as a multiplier of innovation drivers surrounding the firm.[11] The firm is faced with increased market pressure resulting from a relative increase in the number of competitors compared to the home market. Moreover, export activity or the existence of a foreign subsidiary expands the boundaries of the (national) innovation network. That is, openness adds sources of knowledge.[12] A dummy variable on exports – coded one if firms report to have exported in 2003, zero else – is employed to control for openness and foreign market participation. *East Germany, industry dummies:* We further control for a macro location effect (Eastern Germany vs. Western Germany) and heterogeneity among industries.[13]

5 Results

5.1 Descriptive statistics

Table 1 shows some descriptive statistics for a categorization of outsourcing levels. Following Lacity et al. (2009), we distinguish between *In-house* ($\theta_\gamma < 0.2$), *Low* ($0.2 \leq \theta_\gamma < 0.5$), *Medium* ($0.5 \leq \theta_\gamma < 0.8$) and *Complete* ($\theta_\gamma \geq 0.8$). The distribution is skewed to the right. That is, dependent on the assumed weight of 'partial', in between 30% to 50% of the firms in our sample resort to external information technology supply after considering the firm-specific importance of IT. Most strikingly, looking at the means reveals that the proportion of innovating firms varies significantly across classes of outsourcing levels. Independent on γ, the figures suggest a non-linear relationship between product innovation and the outsourcing level, where the maximum is at levels in between 0.2 and 0.5. Minima can be found at levels in between 0.5 and 1. The picture for process innovation is less clear. However, the figures suggest a general positive correlation, i.e. fluctuations around a positive trend.

Firms relying on higher levels of outsourcing seem to be smaller in size, report a worse

[11] Cf. for example the model by Eaton and Kortum (2006), where "a lowering of trade barriers can lead to more specialization in research" (Eaton and Kortum, 2006, p. 26).

[12] This is what is often referred to 'learning by exporting' (Baldwin and Gu, 2004; Damijan et al., 2005).

[13] See Table A.1 in the appendix for an industry classification. As Miozzo and Grimshaw (2005) show in a case study that even organizations from the IT sector are clients in IT outsourcing relationships, firms from the sector 'electronic processing and telecommunication' (NACE 72, 64.2) are included in the analysis. The results are comparable when excluded and available on request.

Table 1: Descriptive statistics

	Outsourcing level							
	In-house $\theta_\gamma < 0.2$		Low $0.2 \leq \theta_\gamma < 0.5$		Medium $0.5 \leq \theta_\gamma < 0.8$		Complete $\theta_\gamma \geq 0.8$	
$\gamma = 0.3$								
Product innovation	0.583	(0.493)	0.640	(0.481)	0.426	(0.497)	0.489	(0.505)
Process innovation	0.659	(0.474)	0.661	(0.474)	0.585	(0.495)	0.702	(0.462)
Log employees	3.975	(1.643)	3.687	(1.560)	3.062	(1.387)	2.342	(1.026)
% University	0.135	(0.225)	0.162	(0.235)	0.225	(0.300)	0.154	(0.273)
Job training	0.824	(0.381)	0.880	(0.325)	0.798	(0.404)	0.872	(0.337)
Business situation	0.663	(0.473)	0.664	(0.473)	0.670	(0.473)	0.553	(0.503)
Export	0.510	(0.500)	0.482	(0.500)	0.277	(0.450)	0.213	(0.414)
East	0.278	(0.448)	0.278	(0.449)	0.234	(0.426)	0.170	(0.380)
IT intensity η	0.393	(0.325)	0.657	(0.272)	0.831	(0.163)	0.971	(0.067)
Observations	1099		342		94		47	
$\gamma = 0.6$								
Product innovation	0.562	(0.496)	0.670	(0.471)	0.493	(0.502)	0.463	(0.503)
Process innovation	0.637	(0.481)	0.696	(0.461)	0.642	(0.481)	0.685	(0.469)
Log employees	3.901	(1.633)	3.951	(1.623)	3.347	(1.504)	2.330	(0.984)
% University	0.119	(0.216)	0.179	(0.240)	0.221	(0.291)	0.150	(0.258)
Job training	0.803	(0.398)	0.895	(0.307)	0.845	(0.364)	0.889	(0.317)
Business situation	0.659	(0.474)	0.661	(0.474)	0.703	(0.459)	0.574	(0.499)
Export	0.495	(0.500)	0.538	(0.499)	0.324	(0.470)	0.204	(0.407)
East	0.278	(0.448)	0.263	(0.441)	0.297	(0.459)	0.167	(0.376)
IT intensity η	0.337	(0.308)	0.636	(0.260)	0.852	(0.152)	0.975	(0.063)
Observations	923		457		148		54	
$\gamma = 0.9$								
Product innovation	0.546	(0.498)	0.678	(0.468)	0.557	(0.498)	0.479	(0.502)
Process innovation	0.626	(0.484)	0.705	(0.457)	0.655	(0.477)	0.667	(0.474)
Log employees	3.827	(1.620)	4.067	(1.631)	3.635	(1.638)	2.737	(1.213)
% University	0.107	(0.210)	0.174	(0.231)	0.195	(0.268)	0.246	(0.310)
Job training	0.787	(0.410)	0.892	(0.311)	0.866	(0.342)	0.917	(0.278)
Business situation	0.644	(0.479)	0.674	(0.469)	0.711	(0.454)	0.635	(0.484)
Export	0.488	(0.500)	0.547	(0.498)	0.412	(0.494)	0.240	(0.429)
East	0.282	(0.450)	0.264	(0.441)	0.278	(0.449)	0.208	(0.408)
IT intensity η	0.307	(0.302)	0.575	(0.258)	0.832	(0.152)	0.967	(0.058)
Observations	811		481		194		96	

Means are reported, standard deviation in parentheses.
Product and process innovation between 2004 and 2006 (0/1).
Natural logarithm of the average number of employees in 2003 (apprentices and part-timers included).
Percentage of employees holding a university degree compared to all employees on average in 2003.
Employees have attended any type of job training in 2003 (0/1).
Good/rather good business situation (0/1) at the time of the interview (2004).
Firm has exported in 2003 (0/1).

business situation, have a lower propensity of exporting and are more often located in East Germany. Further, the descriptive statistics reveal a positive correlation between the percentage of employees with university degrees and the outsourcing level. For moderate levels of γ, however, maxima are at outsourcing levels in between 0.5 and 0.8. Also, the proportion of firms with employees in on-the-job training varies across classes of the outsourcing level. The figures suggest an overall positive correlation, however, there is a kink for outsourcing levels in between 0.5 and 0.8.

5.2 Results of specification A

Estimation results according to specification A are reported in table 2. Coefficients of control variables are strikingly similar across all values of γ. Therefore the tables only report coefficients for models with $\gamma = 0.3$, $\gamma = 0.6$ and $\gamma = 0.9$. In figure A.2 in the appendix, however, the coefficient of outsourcing ($\hat{\beta}$) and the corresponding 90% confidence band is plotted as a function of γ. Regardless of the parameter γ, we cannot find a significant effect of outsourcing on the probability of product innovation in this specification (see left hand panel of figure A.2). Concerning the control variables, the results depicted in the top row of table 2 are not surprising. The estimates suggest that firm size is a significantly positive predictor of product innovation. Also a higher fraction of employees with a university degree increases the probability of product innovation. Firm-specific human capital is not significant for higher values of γ. Our estimates suggest that investment in innovation is pro-cyclical. Export is highly significant and positive. We do not find a significant difference between East and West German firms.

Concerning process innovation, the right hand panel of figure A.2 indicates a significantly positive effect of outsourcing when setting $0.4 \leq \gamma \leq 0.9$. That is, on a very reasonable interval, independent of how we operationalize 'partial outsourcing', external technology supply has a positive and significant effect on client-side process innovation. Also the estimated coefficients for the control variables reported in the bottom row of table 2 are different compared with the results for product innovation. The size effect is larger, however formal education does not play a significant role. However, firm-specific knowledge (measured by job training) seems to be a significant predictor of process innovation. Also, firms in East Germany have a significantly lower probability of process innovation.[14]

Table 2: Probit models for specification A

	$\gamma = 0.3$		$\gamma = 0.6$		$\gamma = 0.9$	
Product innovation						
Outsourcing level	0.2064	(1.13)	0.2160	(1.28)	0.2022	(1.35)
Log employees	0.0961***	(3.91)	0.0958***	(3.92)	0.0949***	(3.91)
% University	0.0054***	(3.20)	0.0054***	(3.14)	0.0053***	(3.10)
Job training	0.1669*	(1.69)	0.1627	(1.64)	0.1603	(1.61)
Business situation	0.1906***	(2.61)	0.1907***	(2.61)	0.1907***	(2.61)
Export	0.6308***	(7.77)	0.6280***	(7.73)	0.6261***	(7.70)
East	-0.1132	(-1.45)	-0.1139	(-1.46)	-0.1151	(-1.47)
Constant	-0.9906***	(-5.68)	-1.0004***	(-5.72)	-1.0016***	(-5.74)
Industry dummies	Yes		Yes		Yes	
Log likelihood	-9.1e+02		-9.1e+02		-9.1e+02	
χ^2	274.2910		274.8184		275.2097	
Pseudo-R^2	0.1559		0.1561		0.1562	
Observations	1582		1582		1582	
Process innovation						
Outsourcing level	0.2864	(1.61)	0.3351**	(2.04)	0.3369**	(2.31)
Log employees	0.1761***	(6.95)	0.1768***	(7.03)	0.1761***	(7.04)
% University	-0.0001	(-0.04)	-0.0002	(-0.15)	-0.0004	(-0.22)
Job training	0.3471***	(3.69)	0.3390***	(3.60)	0.3333***	(3.53)
Business situation	0.2804***	(3.90)	0.2809***	(3.90)	0.2812***	(3.90)
Export	-0.0021	(-0.03)	-0.0072	(-0.09)	-0.0113	(-0.14)
East	-0.2297***	(-3.04)	-0.2295***	(-3.04)	-0.2307***	(-3.05)
Constant	-0.9347***	(-5.56)	-0.9621***	(-5.71)	-0.9742***	(-5.81)
Industry dummies	Yes		Yes		Yes	
Log likelihood	-9.3e+02		-9.3e+02		-9.3e+02	
χ^2	161.5773		162.9138		164.0155	
Pseudo-R^2	0.0858		0.0866		0.0871	
Observations	1582		1582		1582	

z statistics in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
The dependent variables are product innovation and process innovation between 2004 and 2006 (0/1).
Proportion of outsourced IT on total IT weighted by the percentage of computerized workplaces,
where γ gives the weight of 'partial' (see section 3).
See table A.1 for an industry classification, 'other business-related services' is the omitted category.

5.3 Results of specification B

Estimation results according to specification B are reported in table 3. Again, coefficients for control variables are strikingly similar across all values of γ. Therefore the tables only report coefficients for models with $\gamma = 0.3$, $\gamma = 0.6$ and $\gamma = 0.9$. Figure A.3 in the

[14] In some sense, this is in line with the literature on productivity gaps between East and West Germany. See for example Smolny (2010).

Table 3: Probit models for specification B

	$\gamma = 0.3$		$\gamma = 0.6$		$\gamma = 0.9$	
Product innovation						
Outsourcing level	0.8121*	(1.73)	1.1906***	(2.62)	1.5113***	(3.46)
Outsourcing level^2	-0.8017	(-1.35)	-1.2637**	(-2.22)	-1.5842***	(-3.08)
Log employees	0.0931***	(3.77)	0.0866***	(3.50)	0.0797***	(3.22)
% University	0.0054***	(3.19)	0.0054***	(3.19)	0.0056***	(3.29)
Job training	0.1602	(1.62)	0.1536	(1.54)	0.1520	(1.52)
Business situation	0.1872**	(2.56)	0.1849**	(2.53)	0.1831**	(2.50)
Export	0.6238***	(7.67)	0.6128***	(7.52)	0.6030***	(7.38)
East	-0.1188	(-1.52)	-0.1239	(-1.59)	-0.1256	(-1.61)
Constant	-1.0151***	(-5.78)	-1.0316***	(-5.88)	-1.0407***	(-5.97)
Industry dummies	Yes		Yes		Yes	
Slope lower bound	0.8121**	(1.73)	1.1906***	(2.62)	1.5113***	(3.46)
Slope upper bound	-0.7913	(-1.02)	-1.3367**	(-1.80)	-1.6571***	(-2.60)
Extreme point	0.5065		0.4711		0.4770	
90% Fieller-CI	*out of range*		$[0.3594, 0.8335]$		$[0.3985, 0.6186]$	
U-test	1.02		1.81**		2.60***	
Log likelihood	-9.1e+02		-9.0e+02		-9.0e+02	
χ^2	274.7983		277.7270		281.6255	
Pseudo-R^2	0.1569		0.1587		0.1610	
Observations	1582		1582		1582	
Process innovation						
Outsourcing level	0.1874	(0.41)	0.3634	(0.83)	0.3092	(0.73)
Outsourcing level^2	0.1333	(0.24)	-0.0374	(-0.07)	0.0343	(0.07)
Log employees	0.1766***	(6.93)	0.1765***	(6.91)	0.1764***	(6.90)
% University	-0.0001	(-0.04)	-0.0002	(-0.15)	-0.0004	(-0.22)
Job training	0.3481***	(3.70)	0.3387***	(3.59)	0.3335***	(3.53)
Business situation	0.2809***	(3.90)	0.2808***	(3.90)	0.2814***	(3.90)
Export	-0.0009	(-0.01)	-0.0077	(-0.10)	-0.0107	(-0.13)
East	-0.2289***	(-3.02)	-0.2298***	(-3.04)	-0.2305***	(-3.05)
Constant	-0.9308***	(-5.51)	-0.9629***	(-5.70)	-0.9736***	(-5.80)
Industry dummies	Yes		Yes		Yes	
Slope lower bound	0.1874		0.3633		0.3092	
Slope upper bound	0.4540		0.2886		0.3777	
Extreme point	-0.7028		4.8600		-4.5110	
90% Fieller-CI	*out of range*		*out of range*		*out of range*	
U-test	*trivial rejection*		*trivial rejection*		*trivial rejection*	
Log likelihood	-9.3e+02		-9.3e+02		-9.3e+02	
χ^2	161.5438		163.2040		164.1084	
Pseudo-R^2	0.0858		0.0866		0.0871	
Observations	1582		1582		1582	

z statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Slope lower bound $= \beta_1 + 2\beta_2 \cdot 0$, *slope upper bound*$=\beta_1 + 2\beta_2 \cdot 1$.

Extreme point $= -\beta_1/2\beta_2$. *U-test according to Lind and Mehlum (2010).*

appendix plots the coefficients of the outsourcing level ($\hat{\beta}_1$, $\hat{\beta}_2$) and the corresponding 90% confidence band as a function of γ.

For product innovation (left hand panel) we find significant effects when setting $0.4 \leq \gamma \leq 0.9$. The corresponding signs of the coefficients indicate an inverse U-shape.[15] The corresponding maximum is at an outsourcing level of about 0.5.

The right hand panel of figure A.3 indicates similar, yet insignificant estimates of $\hat{\beta}_1$ and $\hat{\beta}_2$ for process innovation. In consequence, we are unable to confirm an inversely U-shaped relation of outsourcing and process innovation. For both models, coefficient estimates of control variables are not largely different from those in specification A.

6 Discussion

To sum up, we find a positive relation between innovation and the outsourcing level. That is, our specification indicates a linearly positive effect of outsourcing on process innovation, and a hump-shaped effect of outsourcing on product innovation.[16] The overall positive effect is in line with earlier studies on KIBS and innovation. The estimated coefficients of control variables such as size, formal and firm-specific human capital, business situation, export and location are meaningful.

Our stylized theoretical model implies both results, dependent on the specificity of knowledge needed to generate innovation. The upper panel of figure 3, with low values of specificity, suggests a monotone increasing relation between knowledge growth and the level of outsourcing. A hump-shaped and monotone decreasing relationship is implied in the lower panel of 3, where higher levels of specificity are depicted.

Inspired by Barras (1986), we assume that product innovation and process innovation differ in terms of knowledge specificity. That is, innovation can be seen as a cycle that starts with process improvements to increase efficiency to go on with process innovations that

[15] A test with the null of a U-shape (negative slope at the lower bound and positive slope at the upper bound) or monotone function (sign of the slope is equal at both bounds) can be rejected for $\gamma > 0.4$. See Lind and Mehlum (2010) for a description of the test.

[16] The fact that the coefficients are insignificant in the respective other specification can be explained by looking at the descriptive statistics in table 1. First, the proportion of firms that report product innovation at the lower end of the outsourcing level does not largely differ from those at the upper end. Second, although there is a kink in the proportion of firms reporting process innovation for a medium level of outsourcing, differences between the lower and the upper end are rather substantial. Figures A.4, A.5, A.6 in the appendix further illustrate our findings.

increase quality, and finally stimulates the development of new products and services. In each stage, more specific knowledge is needed to reach the next stage, i.e. $\kappa_{proc} < \kappa_{prod}$. Hence, if the knowledge needed to generate IT-enabled product innovation is more specific than the knowledge needed to generate IT-enabled process innovation, the empirical results fit the results of our stylized theoretical model quite well.

To see why there are different effects on product and process innovation, consider the case study discussed Kumar and Snavely (2004) as an example. A company from the printing industry decided to develop a new internet-based service that allows its customers to individualize their print projects. Mainly due to a lack of internal competence, the implementation was sourced out and became a success. The outsourcing contract implied that the external vendor was integrated in the internal management process, i.e. it was a partial outsourcing relationship. Kumar and Snavely (2004) stress that vendor-client cooperation was the key driver of success in this case. This example shows that IT-enabled product innovation can be very firm-specific. Process innovation, however, aiming at improvements in productivity and flexibility, may be more common. If IT is widely used for operational tasks, improvements in technology are very likely to have effects on business processes. Hence, IT-enabled process innovation should be easier achieved than IT-enabled product innovation. Given the vendor's relative advantage in IT competence, this argument is even stronger. Also the work of Weeks and Feeny (2008) indicates that in the case of process innovation, trust and communication are less critical for success.

7 Conclusion

While the market for external supply of information technology has seen rapid growth during the last decade, scientific research has been largely silent on an important aspect of client-side effects so far: for firms operating in globalized markets and increasingly individualized customer desires, IT enabled innovation is an important source of value creation.

We employ a stylized theoretical model based on transaction cost economics to explore knowledge creation across the boundaries of the firm. The model suggests that knowledge growth, and therefore innovation, depends on the specificity of knowledge and the scope of outsourcing decisions. When the knowledge needed to generate innovation is not very specific, completely outsourcing knowledge production is always better than cooperation or in-house production. For intermediate levels of specificity, however, the optimal mode of organization is a hybrid one. When required knowledge is more specific, in-house production is optimal.

Our empirical strategy involves to test the theoretical predictions with micro-data collected by ZEW Mannheim. Following a knowledge production function approach, we estimate probit models for product and process innovation. By combining several variables, we construct a measure of the firm-specific importance of IT outsourcing, reflecting both external supply of IT services and firm-specific IT intensity.

The results indicate that outsourcing has an overall positive effect on innovation. We find a linear effect on process innovation, and a hump-shaped effect on product innovation. If innovation can be seen as a multi-staged process of improvements of efficiency and quality that finally stimulates the development of new products and services, then the specificity of knowledge needed is increasing in each stage. That is, if knowledge needed to generate process innovation is less specific than knowledge required to generate product innovation, the empirical results fit the results of our stylized theoretical model quite well.

Nevertheless the study has some limitations. Weigelt and Sarkar (2009) show that vendor characteristics have significant impacts on client innovation adaption. Further work should control for vendor-specific effects if the respective information on the supply-side becomes available.

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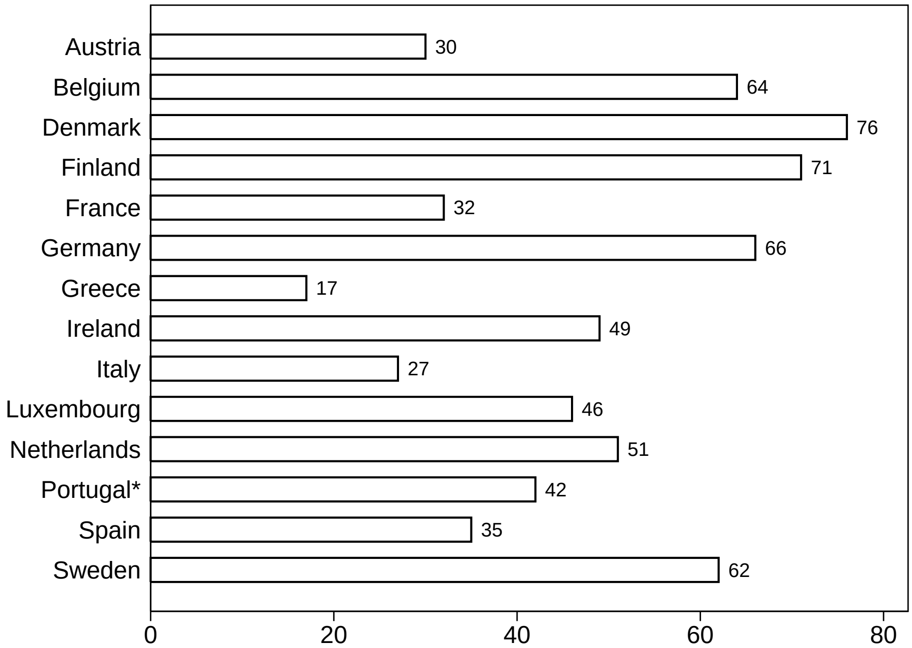
A Appendix

Figure A.1: IT outsourcing in the EU15 countries in 2007



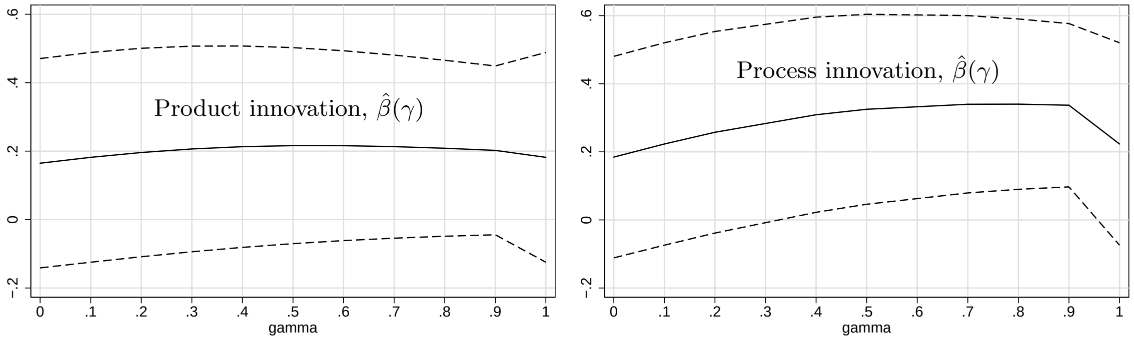
Percentage share of all enterprises with at least 10 persons employed, grouped by sector where external suppliers performed (fully or partly) ICT functions requiring ICT/IT specialists (IT outsourcing*) during 2007. *Due to data restriction without financial sector, data for the United Kingdom is not available.*
Source: Eurostat, information society statistics on enterprises 2007.

Table A.1: Industry classification

Industry	NACE
Consumer goods	15–22, 36–37
Chemical industry	23–24
Other raw materials	25–27
Metal and machine construction	28–29
Electrical engineering	30–32
Precision instruments	33
Automobile	34–35
Wholesale trade	51
Retail trade	50, 52
Transportation and postal services	60–63, 64.1
Banks and insurances	65–67
Electronic processing and telecommunication	72, 64.2
Technical services	73, 74.2, 74.3
Other business-related services	70–71, 74.1, 74.4–74.8, 90

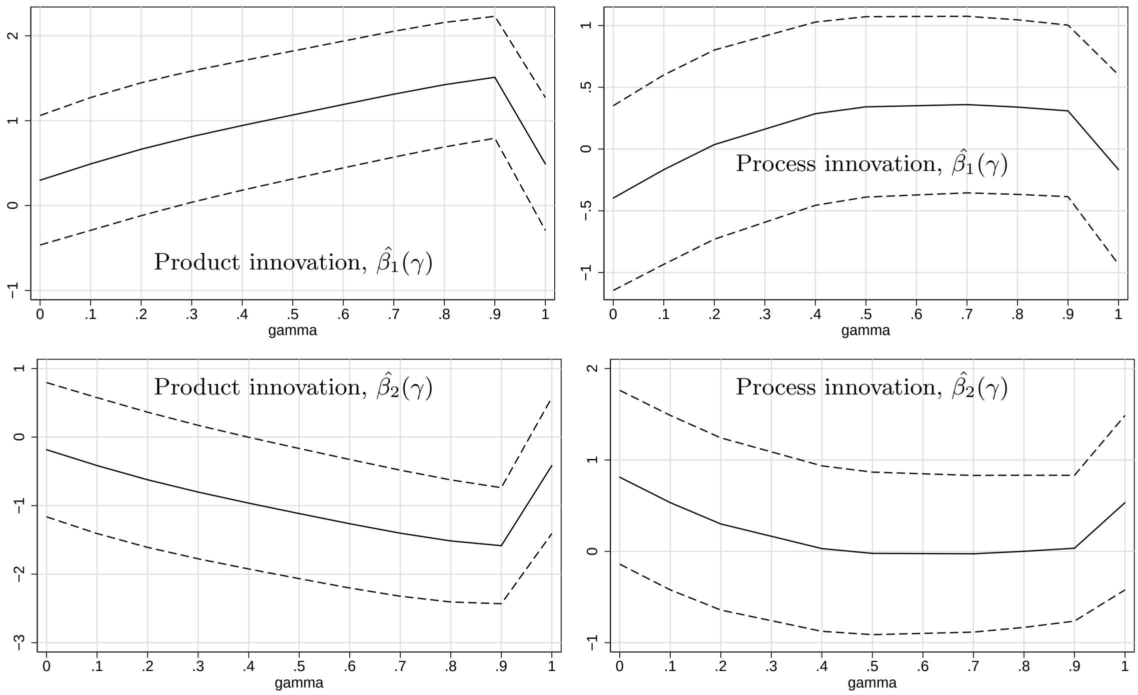
Source: Ohnemus (2007).

Figure A.2: Estimated probit coefficients $\hat{\beta}(\gamma)$, product and process innovation (specification A)



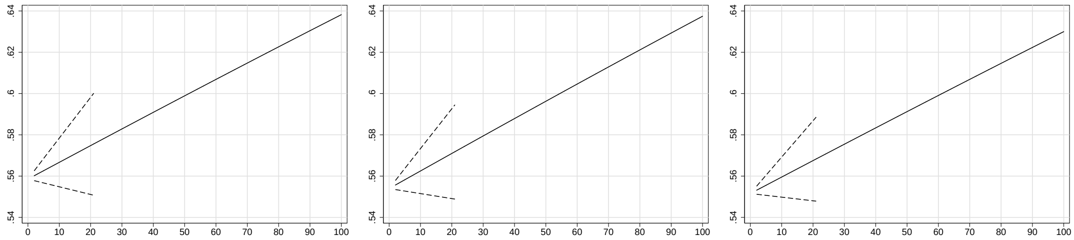
Estimated probit coefficient of outsourcing $\hat{\beta}$ as a function of γ, and 90% confidence interval, according to specification A without squared term.

Figure A.3: Estimated probit coefficients $\hat{\beta}_1(\gamma)$, $\hat{\beta}_2(\gamma)$, product and process innovation



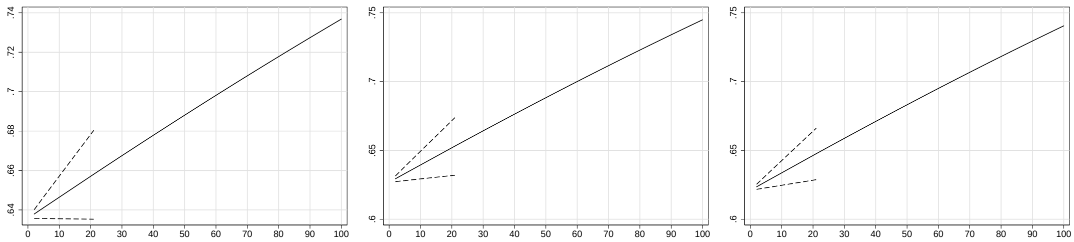
Estimated probit coefficients of outsourcing $\hat{\beta}_1$, $\hat{\beta}_2$ as a function of γ, and 90% confidence interval, according to specification B with squared term.

Figure A.4: Predicted probability of product innovation, γ=0.3, γ=0.6, γ=0.7



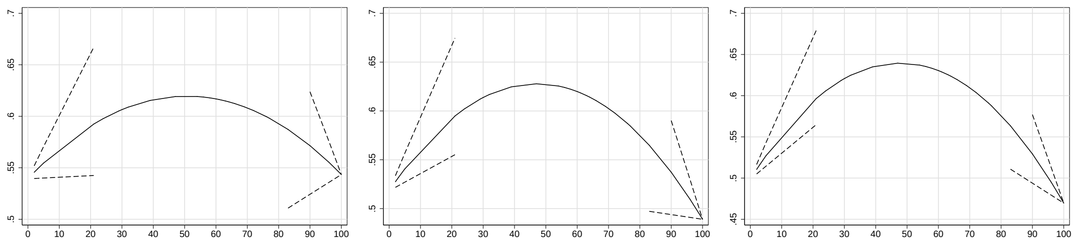
Predicted probability $\widehat{prod}$ as a function of θ, and 90% confidence interval, according to specification A without squared term. All covariates fixed at the mean.

Figure A.5: Predicted probability of process innovation, γ=0.3, γ=0.6, γ=0.7



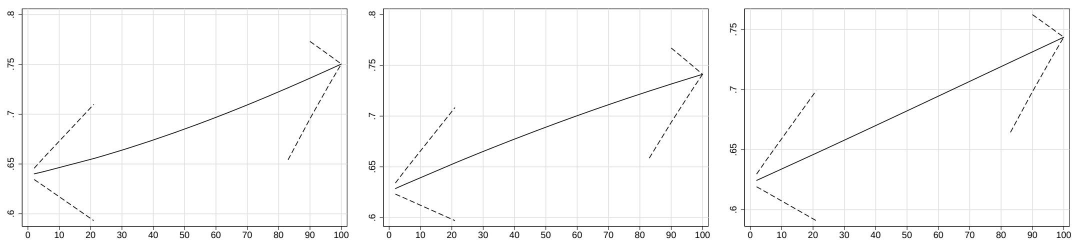
Predicted probability $\widehat{proc}$ as a function of θ, and 90% confidence interval, according to specification A without squared term. All covariates fixed at the mean.

Figure A.6: Predicted probability of product innovation, γ=0.3, γ=0.6, γ=0.7



Predicted probability $\widehat{prod}$ as a function of θ, and 90% confidence interval, according to specification B with squared term. All covariates fixed at the mean.

Figure A.7: Predicted probability of process innovation, γ=0.3, γ=0.6, γ=0.7



Predicted probability $\widehat{proc}$ as a function of θ, and 90% confidence interval, according to specification B with squared term. All covariates fixed at the mean.