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The Impact of E-Procurement on the Number of Suppliers: Where to Move to?

Berlin, May 2006

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Abstract

This paper examines how electronic procurement influences the organization of economic transactions. It seeks evidence for ICT-induced changes in how companies organize their activities and whether ICT lead to more competitive and transparent markets.

Testing the relationship between the effect of electronic procurement on procurement cost and sourcing strategy, I provide new evidence that electronic procurement leads to more market transactions. This leads to the conclusion that electronic procurement increases market transparency, lowers search and supplier switching costs and improves the management of supply chain and contradicts the predictions that ICT will lead to a dominance of network-like organizational form and an increasing reliance on hybrid forms of organizing economic transactions.

Two implications emerge from these results. The first one is relevant for companies engaging in ICT projects. ICT combined with changes in business strategy leads to a reduction of market transaction costs and, as a result, opens up new possibilities in terms of how business activities can be organized and/or how to structure competition in upstream markets. This effect of new technologies is of clear benefit to companies successfully implementing and using new technologies. The second implication is of great importance for companies whose customers implement ICT to intensify competition among suppliers. Changing environment forces them to adapt to new market conditions and look for new ways of maintaining profitability.

Keywords: information technology and firm boundaries, markets vs. hierarchies, sourcing strategy, electronic procurement

JEL classification: L22

1 Introduction

The debate on how Information and Communication Technologies (ICT) influence firm boundaries and the organization of economic activity goes back to the beginning of a rapid proliferation of ICT applications across industries. The immediate conclusion based on the transaction cost theory (Coase 1937) predicted that, as ICT lowers the cost of searching, selecting and monitoring suppliers, companies would move to the market as a form of organizing economic activity (Malone et al. 1987). Despite its logical consistency and explanatory power, the arguments envisaging the rise of markets were confronted with strong critique. Drawing the attention to other determinants of vertical integration, the opponents argued that relationship-specific investments, asset specificity and product complexity effectively prohibit companies from engaging in pure market transactions and frequently internalize transactions as the most efficient remedy against market deficiencies (Bakos and Brynjolfsson 1993, 1993a). Following the Williamson's definition of hybrid organizational form (Williamson 1991), it was argued that a new organizational form will emerge and combine elements of both markets and hierarchies. This alternative paradigm was labelled as a move to the middle.

Despite an intensive debate and the abundance of theoretical arguments, the empirical evidence supporting any of the contradictory paradigms remains scarce. Building on the discussion where companies move to after implementing ICT, this paper seeks for a proof of ICT-induced changes in how companies organize their activities. Another important issue addressed indirectly in this work draws on the question of whether ICT leads to more competitive and transparent markets.

The results reveal that online procurement lead to an increase in the number of suppliers. These observations contradict the predictions that ICT leads to a dominance of network-like organizational forms and supports the view that ICT increases the attractiveness of markets as an organizational form of economic activity. The analysis provides evidence that the motives to move to the market can be explained by the positive impact of ICT on procurement costs.

A noteworthy finding of this work is that firms' structural characteristics play a significant part in what effect ICT has on their sourcing strategies. One interpretation is that firm size and other organization characteristics have implications for the reasons and intensity of ICT usage and, consequently, for the impact on internal work organization, make-or-buy decisions and

relationships with suppliers and customers. In a similar vein, the results indicate that the impact of the technology in question on companies' sourcing decisions varies from industry to industry. These results confirm the intuitive expectation that companies facing different economic conditions and structural characteristics, adopt ICT tools for different reasons.

Two main implications emerge from the results. The first one is relevant for companies engaging in ICT projects. ICT combined with changes in business strategy leads to a reduction of operational costs and, as a result, opens up new possibilities in terms of how business activities can be organized or how to structure competition in the upstream markets. The second implication is of great importance for companies whose customers implement ICT to intensify competition among suppliers. Changing environments force them to adapt to new market conditions and look for new ways of maintaining profitability.

The data used in this paper originate from the e-Business Market W@tch project enabling to analyse the impact of electronic procurement on one aspect of the organization of economic activity, i.e. sourcing strategy. This approach differs from previous research that generalizes the concept of ICT and its implications for firm boundaries.[1] Taking general ICT expenditures or ICT endowment for proxies of ICT usage, this line of research does not account for the fact that various applications are adopted for different strategic reasons and, as a consequence, have different implications for companies' performance, organization of work and relations with customers and suppliers.

The remaining part of the paper is organized as follows: Section 2 reviews the discussion on the impact of ICT on firm boundaries and organization of economic activity. Section 3 describes the data used in the study. Section 4 presents some descriptive statistics illustrating companies' choices regarding the optimal number of suppliers as a function of the electronic procurement deployment. Section 5 founds an analytical framework for the econometric analysis and describes the variables used in the estimated model. Section 6 presents the findings. Section 7 discusses the limitations and contributions of the paper and concludes.

[1] For a literature review on ICT and organizational change see, for example, Forman and Goldfarb (2005).

2 Literature overview

The following literature overview combines the results of research from several fields. It refers to such issues addressed by economics and management science as the make-or-buy decision, firm boundaries and the organization of economic transactions. It begins with an overview of the economic literature on relationships between technologically determined transaction costs and vertical integration. Further, a short literature review summarises the discussion on the ICT impact on firm boundaries, the choice of sourcing strategy and the optimal number of suppliers.

2.1 Move to the market or move to the middle?

In light of the transaction cost theory (Coase 1937, Williamson 1985), decreasing costs of search, evaluation and monitoring of competing suppliers should lead to a shift toward markets as a form of organizing economic activity. Consequently, the expectations regarding the potential of ICT as technologies introducing innovative ways of doing business, re-shaping firm boundaries and changing the constellations of value chains were enormous (Johnston et al. 1988, Milgrom et al. 1990, Fulk et al. 1995). The availability of powerful and cheap ICT was said to increase the attractiveness of markets (Malone et al. 1987, Lucking-Reiley et al. 2001). The authors of the *move to the market* theory argued that companies would reduce their dependency on hierarchy and outsource business activities.

The prophecy of friction-free markets spurred a vivid discussion on the impact of ICT on the organization of economic activity and firm boundaries. Pointing to the fact that inter-firm transactions do not depend only on the cost of searching and evaluating new suppliers, critics deemed the expectations of the new paradigm as premature. The most important elements preventing companies from engaging into pure market transactions include relationship specific investments, asset specificity and market complexity (Klein et al. 1978, Williamson 1979). In order to overcome the problems arising from market deficiencies, companies internalize transactions. In line with this, Bakos and Brynjolfsson (1993, 1993a) argue that companies implementing ICT would benefit from reduced costs of information exchange and processing, but they would not immediately move to markets. Instead, when relationship investments are indispensable or specific assets are procured firms will create networks in which suppliers and buyers form closed business relationships facilitated by ICT (Thompson 2004). The new organizational form was to blend the elements of both markets and hierar-

chies. The paradigm explaining the role of ICT in supporting the transformation towards a hybrid mode was named *a move to the middle* (Johnston et al. 1988a, Clemons et al. 1993, 1994, Hennart 1993).

The notion of ICT facilitating network-like organization structure has been supported by the results of empirical studies. Holland and Lockett (1997) found that the process of supply chain integration is followed by a reduction in the number of suppliers. Dai et al. (2000) concluded that firms indeed benefit from reduced coordination and search costs, but in some contexts buyers still maintain close relationships with selected suppliers and various business models continue to co-exist. Similarly, drawing attention to the fact that the effects of ICT work in favour of both market and hierarchies, Baker et al. (2003, 2004) argued that due to the complexity of business activities and interdependence between various factors determining the organizational form, the final outcome might not depend solely on ICT.

However, other studies indicate that ICT leads to a change in firm boundaries and encourages firms to depend less on hierarchies and conduct more transactions at arm's length. The arguments of Malone et al. (1987) were supported by Hitt (1999) who found that, overall, increased use of ICT was associated with substantial decreases in vertical integration. Examining the relationship between firm size and ICT investment, Brynjolfsson et al. (1994) found evidence that increased ICT expenditures were correlated with decreasing firm size.

Further studies concluded that the impact of ICT on firms and value chains might vary with other aspects. For example, proposing a flexible research framework accounting for ICT, coordination strategy, network structure, asset specificity and market complexity, Holland et al. (1997) analyzed five companies operating in various industries and found that the organizations implemented ICT applications to support both market and network-like forms of organizing transactions. The proportion of market and hierarchy elements was contingent on a range of market, strategy and economic variables. Similarly balanced results presented Mühge (2004) who concluded that as the transaction complexity and asset specificity increase, the coordination effect of ICT enforces hybrid structures and the attractiveness of markets decreases.

Concluding, though the above studies could not rule out other explanations, the results were in general consistent with previous arguments that reduced internal and external coordination costs might lead to vertical disintegration. However, although ICT makes markets more at-

tractive as an organizational form, this relationship seems to be more complex than suggested by the move to the market paradigm.

2.2 The optimal number of suppliers

Though the supplier selection process has a direct impact on the ultimate success of the final product, defining a one-suits-all sourcing strategy seems to be impossible.[2] Even when restricting the number of criteria for selecting a sourcing mode to one (cost), an analysis yields two conclusions. On the one hand, Deming (1986) argues that sole sourcing minimizes buyer's total transaction costs and the costs of achieving quality. By establishing close links with a supplier, the buyer benefits from cost cuts stemming from avoiding downtime and rework and from high quality levels. Porter (1985), on the other hand, maintains that total cost of procurement can be minimized by procuring from more than one supplier.

Beside reducing transaction costs, minimizing risk is an important element of an effective procurement strategy (Cachon 2003). The procurement risk is associated with disruption of supply, price escalation, inventory scheduling, technology access and quality (Trevelen et al. 1988). An important reason behind adopting a particular procurement mode is the reduction of uncertainty related to these factors. For example, a company might adopt a single sourcing strategy with the hope that a close relationship with a supplier will reduce the likelihood of supply disruption and, in addition, will benefit from economies of scale on the input side. Paradoxically, the very same reasoning might lead to selecting several suppliers, i.e. a buyer employing a multiple sourcing strategy might anticipate that supply disruptions decrease with the diversification of supply sources and the competition between suppliers guarantees obtaining the lowest price.

Keiretsu, Japanese industrial clusters, are frequently cited as an example of networks of closely cooperating companies (Helper et al. 2002). However, according to Richardson (1993), the supplier-buyer relationships in the Japanese industries are indeed long lived, but there are usually several firms within the assembler's supplier pool qualified to manufacture a particular component. This observation has been confirmed by Cusumano et al. (1991) who reported an average 1.2 suppliers per component. Thus, a closer look at the structure of keiretsu reveals that even Japanese automakers hardly ever seem to adhere to a single sourcing

[2] For a very comprehensive review of sourcing policies and their determinants see Elmagharby (2000).

strategy and have several suppliers qualified to produce a component. Richardson (1993) calls this strategy parallel sourcing.

A distinctive feature of parallel sourcing is that two or more suppliers with similar capabilities are concurrently sole-source suppliers for very similar inputs. While using a sole source for a component, the buyer establishes parallel sources to provide performance comparisons and competitive bidders for the next period. According to the author, the parallel sourcing model is equivalent to multiple sourcing in terms of the buyer's ability to influence supplier performance with a threat to switch suppliers. At the same time, it is superior to multiple sourcing as it retains the benefits of reduced transaction costs attributed to sole sourcing.

Riordan (1996) argues that second sourcing is particularly appealing under the imperfect information regime. Competition between suppliers effectively reduces rents without hurting their incentives to provide the expected level of effort. As a result, in addition to enjoying the benefits of double sourcing, the buyer solves the problem of incomplete information and chooses the most efficient supplier. Furthermore, in some cases, buyers might have a preference for product variety, be it quality, terms of delivery or payment. In order to obtain the required level of product differentiation, the buyer might split production awards between different suppliers. By awarding a small amount of first period production to a second source, buyers reduce their dependency on a sole supplier and increase the value of the second source in period 2 at a relatively small cost of foregone scale economies in period 1. Concluding, coordination combined with competition seems to be the most cost-effective mechanism for achieving high supplier performance.

2.3 E-procurement and sourcing strategy

Accepting the notion that ICT reduces transaction costs, it is necessary to ask whether ICT leads to a cooperation with a larger number of suppliers, or to a close integration with few partners. The former is suggested by the fact that new technologies lower searching and filtering costs and by increasing the number of sourcing options companies could intensify the competition between suppliers and increase their bargaining position (Mukhopadhyay et al. 2002). However, the latter might be the case because firms can take advantage from transaction economies of scale only if cooperation is maintained over a longer period of time and sufficiently many transactions per relationship are carried out (Clemons et al. 1995). Even with ICT at work, the benefits of inter-firm cooperation are subject to learning curve effects

and in order to fully benefit from integration, both parties need time to comprehend and adapt to the new organization of activities. Thus, it makes sense if a company maintains long-term relationships with fewer suppliers. Furthermore, it is said that the deployment of ICT facilitating the cooperation between a buyer and its suppliers frequently requires some relationship-specific investments. Since these investments are not contractible, a firm has to offer its suppliers some incentives to commit some resources and ensure that once the investments have been made they will earn positive profits afterwards (Bakos et al. 1997). One way to convince a potential supplier to undertake a necessary investment is to reduce bargaining power through limiting the number of sourcing options and/or agreeing to deal with him over a longer period of time.

However, the argument of relationship-specific investment is slowly loosing its validity. Unlike investments in other capital goods, many ICT tools are not necessarily designed for a particular relationship. Hardware is usually standardised and deployable in any relationship and software protocols are gradually evolving towards open systems and modular architectures, independent of a particular industry or business relationship. Thus, as ICT investments are becoming less relationship-specific, companies might benefit of ICT making the markets more transparent and competitive.

According to Morita and Nakahara (2003), the move to the market is not the sole outcome of ICT use. The diffusion of ICT might have a twofold impact on companies sourcing decisions. On the one hand, ICT strengthens the integration between involved organizations. An obvious example of a situation in which the deployment of ICT will reinforce the relationship between buyer and supplier is the procurement of complex products whose design requires a close co-operation between organizations. Due to the highly specific nature of the investments in product design applications and other skills, the manufacturer might decide to sole source a particular component in spite of the benefits of electronic exchange channels. On the other hand, if standardised products are procured, electronic procurement enables manufactures to access a larger pool of potential suppliers and to process information on prices and product characteristics at a low cost. As a result, the number of suppliers from which buyers procure might increase as a result of electronic procurement adoption.

Concluding, electronic procurement enables companies to use markets more efficiently, as it lowers search and evaluation costs and gives access to a larger number of potential suppliers.

However, the impact of electronic procurement on the number of suppliers is subject to asset specificity, product complexity and the necessity for relationship specific investments.

3 Data

The data used in this paper originates from the e-Business Market W@tch project.[3] The main objective of the undertaking includes monitoring the adoption, development and impact of electronic business practices in different sectors of the European economy. It provides sectoral analysis based on sound empirical research, including annual enterprise surveys in all countries of the European Union. So far, within the project three surveys have been conducted. The first one took place in the middle of 2002 and covered over 9260 firms. The second one was performed among 3500 companies in January 2003. The most current data stem from the 2005 survey that covered 5218 firms operating in 10 industries. The surveys focused on the availability and usage of ICT and the perceived importance and impact of e-business at the company level. Apart from the numerous questions relating to the usage and relevance of ICT, all datasets contain background information about each firm, e.g. sector, country of origin, number of employees, size class and number of establishments.

For the purpose of this work I decided to use the data from the March 2003 survey that covered seven industries in five European countries (France, Germany, Italy, Spain and Great Britain). An important advantage of the March 2003 survey over the others is that it had homogenous coverage across all countries and the highest response rate to the question of what was the impact of electronic procurement on the number of suppliers.

For the succeeding analysis I selected three industries: manufacture of chemicals, manufacture of electronics and manufacture of transport equipment. Table A 3 in the Annex presents the definition of the sectors according to the NACE 1 classification. The choice of these three industries was motivated by the high importance of electronic procurement in these sectors. Among the surveyed industries, chemicals, electronic and transport equipment manufacturing industries exhibit the highest rates of online procurement and of shares of online procurement in total purchases.[4] This suggests that the impact of electronic procurement on procurement

[3] For more information see: www.ebusiness-watch.org

[4] For details see the European e-Business Report (2003).

strategies might be more pronounced, compared to other industries in which the diffusion rates and online procurement intensity are lower.

The sample size was 600 for each industry and can be expected to be representative for the entire populations. Common sense suggests that economic conditions in a certain industry might vary from country to country. However, I have not found that country of origin had any statistically significant impact on the studied issue. Presumably, companies in all three industries operate in international environments and are exposed to global competition and deploy similar technologies. Thus, it can be assumed that the impact of ICT on the organization of economic activity are not considerably influenced by the country of origin.

The dependent variable NSI is a discrete choice variable taking value 1 if the number of suppliers increased as a result of online procurement and 0 otherwise.[5] There are two dummy variables that control for firm specific characteristics, i.e. SME indicates whether a company is a small or medium-sized company and EST that controls for the number of establishments. They take vale 1 if a company is a SME or has more than one establishment respectively and zero otherwise. The other independent variables control for type of goods procured online (maintenance, repair and operations: MRO; direct production goods: DIR), and the impact of electronic procurement on procurement costs (positive: PPC or negative: NPC).

Table 3-1 presents the selected variables together with their mean values and standard errors.

Table 3-1 Variable definition and mean values

		Chemicals	Electronics	Transport equipment
Variable*	**Definition**	**Mean**	**Mean**	**Mean**
NSI	Number of suppliers increased	0.20	0.23	0.25
SME	Company is a SME	0.87	0.89	0.86
EST	Number of establishments >1	0.35	0.25	0.34
MRO	Online procurement of MRO goods	0.59	0.64	0.65
DIR	Online procurement of direct production goods	0.54	0.61	0.48
PPC	Positive impact of online procurement on procurement costs	0.47	0.56	0.53
NPC	Negative impact of online procurement on procurement costs	0.03	0.03	0.03
N		193	268	191
* All variables are dummy variables, i.e. Min=0 and Max=1.				

Source: E-Business Watch, March 2003.

[5] A detailed list of questions that served as a basis for the variables can be found in the Annex.

The abstract nature of transaction costs makes including them in an empirical analysis quite a challenging task (Joskow 1988). Testing requires concrete measures of asset specificity and market complexity, as well as a means to assess when and how specific investments are important. With the data at hand, it is not possible to quantify the effect of electronic procurement on transaction costs. Thus, two dummy variables, PPC and NPC, indicate whether the new purchasing method had a positive or negative effect on the cost of procurement process. Both proxies for the relationship between the new technology and its impact on transaction costs are derived from the answers to the question of how electronic procurement affected the cost and the efficiency of companies' procurement processes and should not be confused with the effect of electronic procurement on input prices.

In order to check if the above variables are not too strongly correlated and if there is no multicollinearity problem, I run pair-wise correlation tests for each industry. Table A 5 in the Appendix presents the results. The R-values seem to be at reasonably low level indicating that there is no concern of multicollinearity.

4 Descriptive statistics

In the survey companies that procure online were asked how electronic procurement affected the number of their suppliers. Table 4-1 presents firms' answers. Irrespective of industry, the largest share of firms did not see any change in the size of supplier pool resulting from the introduction of the new transaction channel. Only a small group of firms stated that the deployment of electronic procurement was followed by a decrease in the number of suppliers. There are, however, considerable discrepancies between industries. For example, nearly twice as many companies in the chemicals sector as in the transport equipment industry reduced the size of their supplier base. Further analysis yields some interesting insights as well. Every fifth company in the chemicals industry and every forth firm in the transport equipment increased the number of suppliers after employing electronic procurement method.

Two conclusions emerge from the presented data. First, on average, in 30% of all cases the decision to procure online has been followed by either a reduction or increase of the supplier number. A possible explanation is that ICT technology together with some innovative modifications in procurement processes induce re-thinking of sourcing strategy. Second, in contrast to some prior predictions, a significantly larger group of firms increased the size of their sup-

plier pool, compared to those that reduced it. Finally, there are extensive differences between industries regarding the impact of ICT on the organization of economic activities. This suggests that due to some inter-industry differences with respect to the supply chain organization, the complexity of processed inputs and the importance of relationship specific investments, the impact of ICT on the organization of economic activities varies from sector to sector. Hence, the rationale behind reducing the aggregation level and analysing only homogenous clusters of firms is straightforward. This, however, places some restrictions on the succeeding analysis. Due to a small number of answers, it proved problematic to study the issue of a decreasing number of suppliers at the industry level. Thus, I restricted the analysis to the question of what can be associated with companies decisions to increase the number of their suppliers when introducing a new form of procurement.

Table 4-1. Due to the online procurement the number of your suppliers…

Industry	Increased	Decreased	Remained about the same
Chemicals	0.20	0.09	0.70
Electronics	0.23	0.06	0.71
Transport	0.25	0.05	0.69
Total	0.23	0.07	0.70
In %, N=620 firms.			

Source: E-Business Watch, March 2003.

5 Analytical framework

The principal concern of this paper is to study the relationship between the change of transaction costs caused by the use of electronic procurement and asset specificity and the decision to increase the number of suppliers. The conceptual framework is based on prior theoretical and empirical research and follows similar attempts to study the effect of ICT on the organization of business activities and transactions (for example, see Joskow 1988). It is assumed that asset specificity, product complexity and cost of contacting and managing suppliers affect the sourcing strategy and, hence, the number of suppliers. The following section describes the factors that, according to the previous discussion, might affect the change in company's sourcing strategy.

Product complexity and sourcing strategy

Product complexity raises a variety of transaction costs (Novak et al. 2001). A cost minimizing firm will internalize production if the complexity of inputs is high (Williamson, 1985). In

a similar vein, the level of product complexity is negatively correlated with the number of suppliers a buyer deals with. Thus, taking into account the amount of time and effort that has to be invested in product design, the buyer might prefer to restrict the number of suppliers or even choose sole sourcing.

As already mentioned, for the purpose of this analysis, the measure of product complexity and the associated transaction costs is based on two dummy variables that differentiate between the types of products companies procure online. The first variable, MRO, indicates whether a company purchases maintenance, repair and operations goods online. The second variable, DIR, stands for electronic purchase of direct production goods. I assume that MRO goods are typically standardized goods and of little complexity. Consequently, the availability of technology increasing the attractiveness of markets combined with the low level of product complexity should be positively associated with the tendency to increase the size of supplier pool. In contrast, direct production goods are expected to be of greater complexity, relative to MRO goods. Consequently, independently of the procurement mode, electronic purchase of direct production goods should be negatively correlated with the number of suppliers. It must be noted that the above defined measures of product complexity are based on a very strong assumption, thus both variables are only imperfect proxies. However, justification for their choice provides the fact that in all industries MRO goods are procured online more often than direct production inputs. The difference ranges from 3 percent in the electronics manufacturing industry to as much as 17 percent in the transport equipment producing sector. This might suggest that MRO goods can be easier procured online indeed, compared to direct production products. Based on the above discussion, I formulate the following hypotheses:

> **Hypothesis 1**: Electronic procurement of maintenance and repair goods is positively correlated with an increase in the number of suppliers.
>
> **Hypothesis 2**: Electronic procurement of direct production goods is negatively correlated with an increase in the number of suppliers.

E-procurement and sourcing strategy

As already argued, the cost of searching, evaluating, selecting and collaborating with suppliers have an important implication for the determination of sourcing strategy (Williamson, 1985). It is plausible to assume that there is an inverse relationship between transaction cost and the size of supplier pool. Consequently, other things equal, firms reporting positive im-

pact of electronic procurement on transaction cost are definitely more likely to increase the number of suppliers. The reverse is true for companies whose procurement costs increased due to the electronic procurement implementation. In light of this, I formulate the following hypotheses:

> **Hypothesis 3**: Positive/negative impact of electronic procurement on procurement cost is positively/negatively correlated with an increase in the number of suppliers.

In the following section I empirically analyse the above stated hypotheses.

6 Empirical analysis

As mentioned in the preceding section, the principal concern of this paper is to study the relationship between the decision to increase the number of suppliers and the change of transaction costs caused by the use of electronic procurement and product complexity. To test this relationship, I estimate the following linear model:

(6-1) $$y_i=\alpha + \beta X_i + \varepsilon_i ,$$

where $y_i= 1$, if the number of suppliers increased and $y_i= 0$ otherwise. X_i is a set of firm characteristics and β is a set of parameters. An error term, ε_i, controls for unobserved effects and is assumed to be independent from the explanatory variables. It must be, however, noted that I cannot control for unobserved heterogeneity, i.e. the dependent variable might be influenced by other factors for which no data is available.

The term α represents the baseline probability of reducing the number of suppliers as a result of the decision to procure online. In the context of the previous discussion, however, α might represent the 'administrative burden and costs' of increasing the number of suppliers, other things equal. Consequently, I expect that this term is negative.

I use a logit regression to assess the above model and assume that ε_i is logistically distributed.[6] The probability of electronic procurement leading to an increase in the number of suppliers can be expressed by the following equation (Wooldridge 2003):

(6-2) $$y_i = (P=1| X_i) = 1 / [1 + \exp(-\alpha - \beta X_i)].$$

Table 6-1 presents the regression results. In all cases the model diagnostics indicate that the model as a whole fits significantly better than an empty model.

Table 6-1: Regression results, dependent variable NSI

	Chemicals		Electronics		Transport equipment	
Variable*	**Coefficient**	**Odds Ratio**	**Coefficient**	**Odds Ratio**	**Coefficient**	**Odds Ratio**
SME	1.198*	3.317	1.206*	3.339	-.607	0.545
EST	0.752*	2.121	.601	1.823	-.174	0.840
MRO	1.164***	3.202	.167	1.182	.105	1.111
DIR	-0.465	0.628	.985***	2.678	1.096***	2.992
PPC	1.073***	2.924	.829**	2.290	1.336***	3.803
NPC	- [1]	-	.928	2.530	.978	2.659
Constant	-3.874***		-3.841***	-	-2.102***	
Model diagnostics						
Log likelihood	-82.927		-130.075		-92.717	
N	187		268		190	
Prob > chi2	0.001		0.001		0.000	
Pseudo R2	0.109		0.079		0.118	

Base: Firms procuring online and reporting an impact of electronic procurement on the number of suppliers.

Comparison group: Companies with >250 employees, with one establishment, procuring neither MRO nor direct production goods online, reporting no effect of electronic procurement on procurement costs.

*: significant at 90%, **: significant at 95%, ***: significant at 99%.

[1] NPC dropped, NPC = 0 predicts failure perfectly, 6 observations not used.

In the chemicals manufacturing industry, being an SME and having more than one establishment positively affects the probability of electronic procurement having a positive impact on the number of suppliers. In the electronics manufacturing industry only the SME variable has a positive sign and is statistically significant. The odds ratios of SME variables in the chemicals and electronics industries are slightly greater than 3.3. That is, for an SME in both indus-

[6] The logistic distribution is similar to the normal serving as a base for probit models except in the tails. Both models are, however, comparable and the choice between the two is one of convenience (Gujarati 1995).

tries, the odds of electronic procurement having a positive impact on the size of supplier pool increases by a factor of 3.3.

Though statistically insignificant, both SME and EST variables in the transport equipment have negative signs. Keeping in mind the impact of these variables on the dependent variable in the chemicals industry, this might indicate that the prior considerations suggesting that the effects of ICT on the organization of economic activity vary between industries were correct. In particular, companies from different sectors face different economic conditions and are not alike in terms of ICT intensity usage[7]. Consequently, it can be expected that the impact of ICT on firms' activities mirrors economic regimes in different industries.

Similar conclusions yields from the analysis of variable coefficients measuring the impact of type of goods on the dependent variable. Whereas online procurement of MRO goods positively affects the dependent variable in the chemicals manufacturing industry, it has no significance in other sectors. In contrast, in electronics and transport equipment manufacturing industries DIR variable has a positive and statistically significant impact on the decision to increase the number of suppliers after having started to procure online. In the chemicals manufacturing industry, this variable has a negative, but insignificant effect on the dependent variable. Consequently, the hypothesized effects of MRO and DIR variables were incompletely confirmed in the chemicals manufacturing sector and in the other sectors the results were opposite to the expected. Please recall that both variables controlling for the type of products procured online were to serve as proxies for product complexity. One explanation for such puzzling results might be the imperfectness of these substitutes. Alternatively, the complexity of direct production inputs and MRO goods procured by companies in different sectors might vary. Accordingly, their impact on companies' procurement strategies does not have to be alike across various industries.

PPC, the dummy variable indicating that a company experienced a positive impact of electronic procurement on procurement costs, is positive and significant in all three models. This means that a reduction of procurement costs caused by a new technology and adapted processes offer companies an incentive to increase the number of their suppliers. In other words, these results confirmed the hypothesised effect of lower procurement cost on a company's

[7] For more information regarding inter-industry discrepancies in ICT usage see sectoral reports published by E-business Watch.

sourcing strategy. This conclusion is additionally supported by the fact that in neither industry did NPC have any significant impact on the dependent variable.

It should be noted that the constant term in this estimation has a large negative effect on the probability of electronic procurement leading to an increase in the number of suppliers. This might hint at the general approach toward procurement strategy and, given the specification of the model, can be interpreted as an indirect measure of the administrative burden companies incur by increasing the number of suppliers. Each of the remaining coefficients provides an estimate of its impact on the dependent variable relative to this baseline.

Table 6-2 presents the estimated probabilities that electronic procurement leads to an increase of the supplier number as a function of DIR and PPC in the transport equipment industry. The positive impact of electronic procurement on the procurement cost is by far the most important determinant of a positive change in the number of suppliers. Lower transaction cost raises the probability of electronic procurement leading to an increase of the sourcing pool from 2 percent to 22 percent for non-direct production goods and from 16 percent to 63 percent for production inputs. Though not to such a high extent, procuring direct production goods increases the probability of electronic procurement boosting the number of suppliers as well.

Table 6-2: Estimated probabilities that e-procurement leads to an increase of supplier number

Transport		**PPC** (52.88)	
		0	**1**
DIR (48.17)	**0**	0.02	0.22
	1	0.16	0.63

Specifically, the probability that e-procurement leads to an increase of supplier number is $F(-2.102 + 1.096*DIR + 1.336*PPC)$ where F is the cumulative normal distribution function.

Mean values in parentheses.

7 Conclusions

This paper has been motivated by the prevailing gaps in understanding of how ICT affects firm boundaries and organization of economic activities. The results of this work reveal that at least one out of five companies that procure goods online increased the number of their suppliers. In contrast, a small fraction of firms reduced the size of their supplier pool. This *move to the market* can be explained by the transaction cost theory, i.e. as electronic procure-

ment lowers the cost of searching, selecting and monitoring suppliers, it encourages firms to a more extensive use of markets.

A noteworthy finding of this work is that a firm's structural characteristics play a significant part in what effect ICT has on their sourcing strategies. In two out of three industries, the variables controlling for firm size had a significant impact on the likelihood of a firm increasing its number of suppliers. This indicates that the impact of ICT on internal work organization, make-or-buy decisions and relationships with suppliers and customers is not alike for every company.

Furthermore, the results indicate that the impact of the technology in question on companies' sourcing decisions varies from industry to industry. In the same way, the type of goods procured online might have various consequences for sourcing strategies of companies operating in different industries. These results confirm only the intuitive expectation that when facing different economic conditions and structural characteristics in a particular industry, companies adopt ICT tools for different strategic reasons which, in turn, has different implications for companies operating in various industries. An immediate inference is that any further research aiming at identifying the impact of ICT on the organization of economic activities should concentrate on comparable groups of firms, operating in homogenous economic environments.

Despite delivering some novel insights, the study suffers from some limitations. First, the dependent variable used in the estimation merely mirrored the perceived impact of electronic procurement on the number of suppliers and did not allow to control for other causes of the variation in the suppliers number. Second, I formulated very strong assumptions regarding the level of product complexity and the type of goods that companies procure online. I argued that MRO goods are, in general, less complex than direct production inputs. This, however, does not necessarily have to be true in every case. For example, spare parts, categorised as MRO products, procured by a chemical company to keep a customized piece of equipment running might be more complex than commodities bought on spot markets. This, in turn, shall have an opposite effect on the sourcing strategy than predicted. Last, similar to the dependent variable, the measures of the impact of electronic procurement on procurement cost are far from being perfect. They can be neither quantified nor checked against other performance indicators. Consequently, both PPC and NPC constitute only imperfect substitutes for the effect of electronic procurement on procurement costs.

An important implication for future research on the impact of ICT on the organization of economic activity is the issue of the data availability. There are already some studies on the topic but they usually take general ICT expenditures for proxies of ICT usage and, consequently, fail to account for the fact that various applications are adopted for different strategic reasons and, as a consequence, have different implications for companies' performance, organization of work and relations with customers and suppliers. Focusing on one particular ICT application and its effect for how companies organize economic activity seems to be a more appropriate approach. So far, this way of analysis has been strongly limited by the availability of appropriate data. In addition, in order to obtain a complete picture, future studies should incorporate the contradictory effects of various ICT technologies on companies' make-or-buy decision, sourcing strategies and work organization.

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Annex I: Endogenity problem

The variables used in this analysis were derived from answers to questions about the perceived impact of electronic procurement on the number of suppliers and the cost of the procurement process. The lack of 'hard data' on the discussed issues poses significant limitations on the analysis. First, relying only on 'personal' judgements of the respondents raises the question of the credibility of the answers. Second, the subjectivity of the expressed views makes it difficult to define exactly what influenced what. For example, lower costs of the procurement process might be a result of a decrease in the number of suppliers that followed an introduction of electronic procurement, in contrast to the approach taken in this work. This distinction can be difficult to make and the direction of causality effects might be problematic to determine.

Thus, although the formulation of the questions does not leave any doubt regarding what influenced what, I performed two additional tests to rule out the problem of endogenity. One tested the impact of all variables integrated in the first model but the variables accounting for the impact of electronic procurement on procurement cost. The second included PPC as a dependent and NSI as an explanatory variable. Though it would be prudent to run a similar analysis in which NPC would be a dependent variable, the number of companies reporting a negative impact of electronic procurement on procurement cost is too small to test such a model.

Table A 1 presents the results of the first test. All modes passed the null hypothesis test, i.e. the explanatory power of these models is greater, compared to empty models. Since, none of these models explains the changes in the dependent variable better than the models with PPC and NPC variables, I conclude that that there is a significant correlation between the effect of electronic procurement on procurement cost and the change of sourcing strategy.

Compared to the regression results in Table 6-1, there are changes in the coefficient values. For example, coefficients of SME and EST in the first regression decreased. This might be a sign of interaction effects between these and the omitted variables. However, as the pair-wise correlation test revealed, there is no problem of multicollinearity (see Table A 5).

Table A 1: Regression results, dependent variable NSI, variables PPC and NPC omitted

	Chemicals	Electronics	Transport equipment
Variable*	**Coefficient**	**Coefficient**	**Coefficient**
SME	.980	1.293*	-.663
EST	.668	.612*	-.128
MRO	1.091**	.314	.0508
DIR	-.287	1.003**	1.133**
Constant	-3.139***	-3.494***	-1.209*
Model diagnostics			
Log likelihood	-88.452	-133.254	-98.785
N	193	268	190
Prob > chi2	0.02	0.003	0.012
Pseudo R2	0.062	0.057	0.061

Base: Firms procuring online and reporting an impact of electronic procurement on the number of suppliers.

Comparison group: Companies that did not increase the number of their suppliers after starting to procure online, with >250 employees, with one establishment, procuring neither MRO nor direct production goods online.

*: significant at 90%, **: significant at 95%, ***: significant at 99%.

Table A 2 presents the results of a logit regression in which PPC is the dependent variable and NSI serves as one of the explanatory variables. Again, as in the model tested in Section 6, there is a positive and strong correlation between PPC and NSI. However, as it runs contrary to the theoretical prediction, it is implausible to assume that an increase in the suppliers number had a positive impact on the procurement process cost. Regardless of the decision to adopt electronic procurement, only if a firm increased the efficiency of the procurement process and, subsequently, reduced the cost of sourcing activities, it could increase the number of its suppliers in order, for example, to increase the competition in the upstream market. The other option, i.e. lower procurement cost as a result of an increase of the suppliers number, seems rather unlikely.

Concluding, the results presented above indicate that whenever online procurement enables a company to reduce its procurement costs, the likelihood of increasing the number of suppliers rises. Although no causality test was conducted here, it can be accepted that new technology reduced transaction cost and lead to a change of sourcing strategy. This conclusion can be generalized, as irrespective of the sector, companies benefiting from lower procurement costs are likely to move to the market and benefit from intensified competition between suppliers. Unlike in the case of the change in procurement cost, I could not determine a universal effect of the types of goods procured online on the supplier number for all industries. The inconsis-

tencies of results can be attributed to either the inter-industry differences or the imperfectness of the proxies for product complexity.

Table A 2: Regression results, dependent variable PPC

	Chemicals	**Electronics**	**Transport equipment**
Variable*	**Coefficient**	**Coefficient**	**Coefficient**
NSI	1.129***	.751***	1.269***
SME	-.335	.732	-.283
EST	-.145	.372	.0313
MRO	-.103	.539***	-.0693
DIR	.356	-.030	.227
Constant	-.121	-.980*	-.006
Model diagnostics			
Log likelihood	-128.627	-176.823	-123.858
N	193	268	190
Prob > chi2	0.085	0.015	0.01
Pseudo R2	0.036	0.038	0.058

Base: Firms procuring online and reporting a positive impact of electronic procurement on procurement cost.

Comparison group: Companies that did not increase the number of their suppliers after starting to procure online, with >250 employees, with one establishment, procuring neither MRO nor direct production goods online.

*: significant at 90%, **: significant at 95%, ***: significant at 99%.

Annex II: Variables definition

Table A 3. Sector definition of e-Business Watch survey March 2003

Sector name	**NACE Rev. 1 Codes and definitions**
Chemicals	24 Manufacture of chemicals, chemical products and man-made fibers 25 Manufacture of rubber and plastic products
Electronics	30 Manufacture of office machinery and equipment 31.1 Manufacture of electric motors, generators and transformers 31.2 Manufacture of electricity distribution and control apparatus 32 Manufacture of radio, television and communication equipment and apparatus
Transport equipment	34 Manufacture of motor vehicles, trailers and semi-trailers 35 Manufacture of other transport equipment

Table A 4. Variables and survey questions (e-Business Watch March 2003)

Variable	**Survey questions**	**Survey answers**
NSI	What effect has online procurement had on the number of your suppliers? Has the number ...	(1) increased (2) decreased (3) remained about the same (4) DK
SME	Would you be able to tell me to which of the following size groups your company belongs?	(1) 1 - 9 employees (2) 10-49 employees (3) 50 - 249 employees (4) 250+ employees (5) DK/ no answer
EST	Does your company have only one establishment, or more than one establishment? By establishment we mean a single identifiable unit at a particular address.	(1) only one establishment (2) more than one establishment (3) DK
MRO	Does that include the purchase of (a) goods for maintenance, repair and operations, also called MRO goods?	FOR EACH: (1) yes
DIR	(b) goods which are used as parts of the products or services which your company offers, that is direct production goods?	(2) no (3) DK
PPC	According to your experience, what effect has online procurement on the procurement costs?	(1) very positive (2) fairly positive (3) neither positive nor negative
NPC		(4) fairly negative (5) very negative (6) DK

Table A 5. Pair-wise correlations between the explanatory variables

Chemicals						
	SME	EST	MRO	DIR	PPC	NPC
SME	1					
EST	-0.4181**	1				
MRO	0.0993	0.0391	1			
DIR	0.0654	0.0120	0.0533	1		
PPC	-0.0225	0.0089	0.0152	0.0728	1	
NPC	0.0707	0.0575	0.0295	-0.0758	-0.1692*	1
Electronics						
	SME	EST	MRO	DIR	PPC	NPC
SME	1					
EST	-0.4211**	1				
MRO	-0.0874	0.0762	1			
DIR	0.0895	-0.0485	0.0158	1		
PPC	0.0782	0.0434	0.1297*	0.0272	1	
NPC	-0.0183	-0.0946	0.0260	0.0356	-0.1846**	1
Transport equipment						
	SME	EST	MRO	DIR	PPC	NPC
SME	1					
EST	-0.4332**	1				
MRO	0.0212	0.0054	1			
DIR	-0.1201	0.1785*	0.0835	1		
PPC	-0.0820	0.0516	-0.0022	0.1123	1	
NPC	0.0665	-0.1172	-0.0188	-0.0924	-0.1737*	1
Pearson's correlation coefficients, ** signifficant at .99 level, * signifficant at .95 level.						