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Why IT matters – An empirical study of e-business usage, innovation, and firm performance

Berlin, Juni 2005

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IMPRESSUM

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ABSTRACT

The article argues that IT continues to have strategic relevance for companies because it enables innovation. A conceptual link between the adoption of IT and innovation is established. This conceptual link allows a market-based, economic explanation for variations in IT payoffs among firms: The successful adoption of new IT leads to innovation. Depending on the behavior of customers and competitors, a successful innovation can enable companies to gain competitive advantages. The economic theory of innovation suggests conditions that are necessary for firms to benefit from innovative activities.

The relevance of IT as an important enabler of innovation is demonstrated using a very large sample of enterprises from different industries and countries in the European Union surveyed in late 2003. It is shown that a substantial share of firms use IT to introduce new processes into their business, or to offer new products or services to their customers. To study the relationship between firm performance and innovation, I estimate an error component model that controls for unobserved market-specific effects and various firm-specific characteristics. The regression results indicate that innovative firms are generally more likely to exhibit increasing turnover and employment. In addition, firms that conduct product or service innovations are also more likely to be profitable. Furthermore, enterprises using IT to innovate perform at least as well as those innovating without IT. Yet, no significant relationship between process innovation and profitability is found, suggesting that firms might have problems to appropriate excess profits from process innovations, independent from whether they are enabled by IT or not. Possible reasons for this include time-lags between process innovations and profit gains, problems to effectively protect process innovations from imitation by competitors, or a lack of complementary resources. The results suggest that the returns to IT critically depend on whether and how IT investments are transferred into innovative activities. In addition, they suggest that IT will maintain its strategic importance as long as the IT industry remains innovative in developing new IT hardware and useful new business applications for it.

INTRODUCTION

In a much debated article, Nicholas Carr (2003) argued that information technology (IT) doesn't matter anymore as a strategic device for companies to gain competitive advantage. His reasoning was both simple and convincing: As IT becomes ubiquitous, it turns into an infrastructure technology (just like electricity or telephones) possessed by everyone, instead of a resource that is only available to few. Therefore, IT loses its potential for creating sustainable competitive advantage because it is scarcity, not ubiquity, that enables a company to gain an edge over rivals. Carr concludes that IT should be viewed and managed as a commodity and not as a strategic asset.

Yet, Carr's argument is not entirely correct because it overlooks an essential property of information technology: IT creates numerous, company-specific opportunities to improve processes and to generate new products and services for customers that did not previously exist. Hence, IT is inherently strategic because it enables innovation and is therefore a medium to competitive advantage. However, it is not IT per se that matters, but what firms do with it. Hard- and software tools offer sets of technologically feasible opportunities. But they can often be customized and they leave degrees of freedom with the user to decide how, when, or for what purpose the technology will be used. One and the same IT tool can have varying impacts on two different firm (Chan 2000). Hence, the impact of IT on performance is indirect and depends on how firms decide to utilize the technology, to what extend they take advantage of a new technology to introduce innovations to their business, and whether this innovation can be perfectly copied by rivals or not.

On the conceptual level, IT can be viewed as an enabler of process innovation from the perspective of the adopter, if the implementation succeeds, the routines are changed and the new system is actually utilized. IT can also act as an enabler of product or service innovation from the perspective of the adopter, if it is successfully used to offer a new service or to deliver products to customers in a way that is new to the enterprise. For example, a company that adopts and implements a new online shop software usually changes the routines of how incoming orders are being processed. This is a process innovation. Also, the new online shop

software may allow the firm to deliver its products to customers in a new way or to offer additional services, such as tracking orders online or getting immediate information about availability. This would be a service innovation.

This conceptualization of IT as an enabler of innovation is consistent with Schumpeter's (1934) definition of innovation as "the carrying out of new combinations". The conceptual link between IT adoption and the economic theory of innovation allows a market-based approach to study why IT investments are not directly linked to performance and why different firms investing in the same technology may exhibit different payoffs. Thus, this conceptual link can help us to understand how IT investments are related to strategy and sustainable competitive advantage.

Innovation is of strategic relevance because it fulfills two purposes: Firms conduct innovation because they seek profitable investment opportunities and they seek to give themselves a strategic advantage over their rivals. A strategic advantage may occur because a superior production methods or a better product or service can enhance a firm's market share. In addition, depending on the novelty and its degree of substitutability, a product or service innovation may yield a temporary or sustainable monopoly position to the innovating firm (Schumpeter 1934). If a firm knows that its rivals are engaging in process innovation or product/service improvements, it will see its own competitive position as being under threat. This creates an incentive to also invest in innovation in order not to lose out to rivals (Beath et. al. 1995, Götz 1999). Information technology, as a potential enabler of innovation, consequently does have strategic relevance.

From this reasoning, four main questions arise that are addressed in this empirical study. First, how much innovation is actually enabled by IT, in particular by Internet-based technologies? Second, do innovative firms generally perform better? Third, how are IT-enabled innovation and non-IT-enabled innovation related to different measures of firm performance? And fourth, does a high endowment with IT correspond to superior performance?

In this study, organizational performance is measured in terms of profitability, turnover development and employment development. The focus of the analysis in on the relationship between these performance variables and four different kinds of innovation, including IT-related and non-IT-related innovations for either internal processes or new products and services.

A frequent issue in studies of organizational performance is the identification of causality (March and Sutton 1997). With respect to the relationship of innovation and organizational performance, the question is whether firms' perform well because they are innovative, or if they are able to innovate because they perform well. It is not the purpose of this study to resolve this question, and the results of the study can be interpreted in both ways.

Yet, the presented empirical evidence is sufficient to demonstrate that IT can matter for gaining competitive advantage because it enables innovation. More important than the absolute endowment with information technologies is whether and how firms use them to conduct innovation. Also, the study is unique because it provides new insights into the relationship between IT- and non-IT-based innovative activities and performance measures. The results suggest that IT-based innovations are not inferior to other kinds of innovation and that appropriability problems can occur with both IT- and non-IT-based innovations. The econometric model introduced in this article is particularly suitable to study organizational performance because it allows to control both for unobserved firm- and market-specific effects that can influence corporate performance. The data set used here is also unique because it is timely, containing a very large sample of enterprises from various sectors and countries in the European Union, and because it allows to differentiate between IT-based and non-IT-based innovation. Together, the data and the methods used in this study enable a more differentiated discussion about the strategic relevance of IT and they are relevant both for researchers and practitioners.

The article is organized as follows: Succeeding this introduction, the theoretical background of this study and a short overview of related literature is provided in section 2. The econometric estimation model is motivated and derived in section 3. Section 4 describes the data set and reports some descriptive findings. The regression results are presented in section 5 and discussed in section 6. Limitations of the analysis are pointed out in section 7. Finally, section 8 concludes the paper.

THEORETICAL BACKGROUND

Various scholars have stressed the importance of innovation for corporate performance. Audretsch (1995) finds that new firms that are able to innovate experience higher growth rates and greater chances of survival. Cefis and Marsili (2003) also find a positive effect of innovation on firms' survival. In addition, their findings suggest that small and young firms can benefit most from innovation in order to survive in the market. Geroski et al. (1993) show that successfully innovating firms are more profitable due to the direct effect of the new product or process, and because of the indirect effect associated with the transformation of a firm's internal capabilities that enable the firm to better profit from knowledge spillovers and relative insensitivity to macroeconomic shocks. Mansfield (1968) reports that innovators are more likely to grow than other firms during the years after an innovation. Czarnitzki and Kraft (2004) report better credit ratings among innovative firms up to a certain threshold, whilst too many innovative activities reduce the rating. Griliches (1981) and Blundell et al. (1999) report greater stock market values for innovating firms.

Despite these generally positive impacts of innovation on performance, many innovating firms fail to obtain significant economic returns from an innovation, while customers, imitators and other industry participants benefit. Thus, there are often appropriability problems for the innovator because of the difficulties to protect the innovation from imitation by rivals (Levin et al. 1987, Teece 1987). To accommodate, firms typically try to appropriate private returns from innovation with a range of mechanism, including patents, secrecy, lead time advantages and the use of complementary capabilities (Cohen et al. 2000). Methods of appropriability vary markedly across and within industries and not all methods work well in all cases.

Patents rarely yield perfect appropriability because they can be "invented around" at modest costs and are only effective in a few industries (Harabi 1994, Teece 1987). Arundel (2001) presents survey results showing that a higher percentage of firms in all size classes rate secrecy as more valuable than patents. Levin et al. (1987) and Harabi (1994) find evidence that for process innovations lead time is the most effective means of appropriability. For product innovations, superior sales and service efforts are most effective, followed by lead time. Baumol (2002) stresses that the advantages of being first to innovate have successfully sped

up the pace of technological progress in free market societies, because “time is money”.

A different stream of literature analyzes the firm-level impacts of IT investments on performance variables, without linking them explicitly to innovation. The effect of IT investments is still subject to debate, because not all studies have demonstrated clear payoffs from IT investment (Chan 2000, Kohli and Devaraj 2003). Also, the results vary depending on how performance and IT payoffs are measured and analyzed. For example, Hitt and Brynjolfsson (1996) find positive impacts of IT investments on productivity, but not on profits. Prasad and Harker (1997) did not find positive effects of IT capital on productivity, while IT labor positively contributed to output and profitability.

Positive effects of IT spending on firm-level productivity are reported, for example, by Brynjolfsson and Hitt (1996, 2000, 2003), Greenwood and Jovanovic (1998), and Bertschek and Kaiser (2004). Many of these studies stress that the effect of IT on productivity is rather indirect, arising if IT investments are combined with complementary investments into work practices, human capital, and organizational restructuring.

Analyzing the profitability of IT, Stoneman and Kwon (1996) show that the profits of non-adopters of IT are reduced as other firms adopt new IT and that the gross profit gains of IT adoption are related to firm and industry characteristics and the number of other users of the technology. Similarly, Weill (1992) suggests that early adopters of IT are likely to benefit, but once the technology becomes common the competitive advantage is lost.

Analyzing the effects of IT investments on firm level growth, Devaraj and Kohli (2000, 2003) find positive effects of IT investments and IT usage on revenue development in the health care sector. Using data from the insurance industry, Harris and Katz (1991) found that top performing firms with high premium income growth had higher IT expense ratios and lower non-IT costs. Weill (1992) found positive effects of IT investment on sales growth among valve manufacturing firms.

In a meta analysis of studies on IT payoff, Kohli and Devaraj (2003) find that positive impacts of IT on performance are more likely to be found in studies using large data sets from primary sources. Also, studies using longitudinal firm-level data that allow to control for time-lag effects are more likely to find positive impacts of IT. Results tend to vary greatly among different industry sectors. In addition, different results tend to be reported for different

kinds of dependent variables being analyzed. Generally, more studies suggest positive impacts of IT investments on productivity and growth than on profitability.

Variations in performance outcomes of firms investing into IT can be related to firm-specific resources that are unequally distributed among firms (Melville et al. 2004, Bharadwaj 2000). This reasoning is related to the resource-based view of the firm (Barney 1991) that proposes that firms could obtain competitive advantage based on firm-specific resources that are specific, valuable, rare, imperfectly imitable, and not strategically substitutable by other resources. Following the resource-based view, Santhanam and Hartono (2003) find that IT capability is related to superior firm performance. Richardson et al. (2003) show that performance differences can be attributed to the IT conversion capability of firms, which is conceptualized as reflecting the ability of firms to leverage the potential of information technologies.

The resource-based view, which focuses on firm-internal factors influencing performance differences, can be complemented by the conceptual link between IT adoption and innovation that is proposed in this article. In particular, a possible reason why various studies did not find positive relationships between IT investments and performance is because it is not the investment into new technology per se that determines performance, but how these investments are transformed into process and service innovations. Firm-specific resources such as managerial skills, know-how, experience, the presence of technical experts and prior technological investments may be responsible for the ability of firms to transfer IT investments into innovation. After the IT investment has successfully triggered an innovation within the firm, the performance outcome of the investment will depend on the type of the innovation that was carried out and the market response of competitors and customers. In this context, the timing of the innovation is important and the appropriability strategy of the firm, i.e. the ability of the firm to protect its innovation from imitation by competitors.

AN ERROR COMPONENT MODEL OF FIRM PERFORMANCE

It is obvious that, besides innovative activities, numerous other factors also influence the performance of an enterprise. For example, this includes the market in which a firm operates (Dunne, Roberts and Samuelson 1988, 1989), the presence of economies of scale and the size of the firm, the prevailing market structure and the market share of the enterprise, as well as firm-internal structures and resources, including the technology the firm uses, its organizational structure, human resources, and managerial competence. Lenz (1981) provides an interdisciplinary summary of numerous "determinants" of organizational performance.

Hence, in order to identify the relationship between innovation and firm performance, one needs to control for alternative factors that influence performance. The challenge in this study (as well as in most other studies with a similar objective) is that not all factors that could play a role are actually observable in the data.

Because we cannot observe all relevant factors, we have to make some preferably non-critical assumptions about them. For this purpose, an error component model of firm performance is introduced that enables to control separately for firm-specific and market-specific unobserved effects when estimating the influence of the observable characteristics on performance variables. This enables to disentangle the effects of unobservable market characteristics and the effects of the observable firm level characteristics, for which we obtain coefficient estimates.

We observe a cross-section of a large number N of heterogeneous firms with index $i = 1,...,N$. Each firm operates primarily on one market, and there are J different markets with index $j = 1,...,J$. We are interested in the performance of firm i in market j, which is recorded in the dependent variable y_{ij}. Performance depends on a vector of observable firm-specific characteristics $\overline{x}_{ij}$. In addition, performance also depends on unobservable market-specific effects u_j and unobservable firm-specific effects ε_{ij}. Thus, performance is a function of various firm-specific characteristics and two unobservable error terms:

$$y_{ij} = f(\bar{x}_{ij}, u_j, \varepsilon_{ij}) \quad (1)$$

In this study, $\bar{x}_{ij}$ consists of the following variables:

x_1 = dummies indicating four different kinds of innovative activity

x_2 = firm size (measured by number of employees in four categories)

x_3 = market share (measured in % in six categories)

x_4 = % of employees with a university degree

x_5 = number of e-business technologies installed by the firm

The technologies which are included in x_5 and their relative frequency of occurrence are listed in Table 1. A more detailed description of the data follows on page 11.

Table 1 - Relative frequencies of 7 e-business technologies, Nov 2003

Technology	**Occurrence in sample**
E-learning	7.7%
Customer Relationship Management System (CRM)	8.9%
Online purchasing	37.8%
Online sales	13.8%
Enterprise Resource Planning System (ERP)	9.4%
Knowledge Management System (KMS)	5.5%
Supply Chain Management System (SCM)	3.3%
N=7,302. Unweighted results. Abbreviations in ( ) indicate variable names for the regression analyses.	

The economic conditions within one market are comparable for all firms operating in that market, but they can vary greatly among markets. Hence, u_j is equal for all firms operating in market j, but u_j can vary. All relevant firm-specific effects are captured in ε_{ij}. Identification requires to assume that ε_{ij} is independent of all observable factors $\bar{x}_{ij}$.

Yet, the advantage of the model is that we do not need to assume that the market-specific effect u_j is independent from the firm specific effect ε_{ij}, $E[u_j \mid \varepsilon_{ij}] \neq 0$. Also, we do not assume independence of u_j from the observable firm-specific characteristics $E[u_j \mid \bar{x}_{ij}] \neq 0$. Clearly,

such an assumption would violate basic economic reasoning. Consider the relationship of market structure and the observed market share of an individual enterprise: If a market is characterized by perfect competition, we will not expect to find a firm with a high share in that market. Vice versa, a highly concentrated market may only exhibit a low number of firms with high market shares. Hence, market structure and market share of each firm are correlated. In our case, it is possible to observe the market share of each firm in the data, but we do not know the exact market structure in which each firm operates. However, this unobservable market structure, which is captured in u_j, is very likely to effect firm performance. Similar arguments can be made with respect to the other observable characteristics.

We consider a qualitative indicator variable y of firm performance that takes a value of $y = 1$ if a specific criteria is observed, and $y = 0$ otherwise. For example, y could be profitability taking a value of $y = 1$ if the firm has been profitable last year and $y = 0$ otherwise. Hence, y is a Bernoulli distributed random variable and the occurrence of y is conditional on various observable and unobservable characteristics, as defined in (1). Assuming that the influence of the conditional characteristics is linear, the probability that a firm observes $y = 1$ can be written as

$$p_{ij} = \Pr[y_{ij} = 1 \mid \bar{x}_{ij}, u_j] = E(y_{ij} \mid \bar{x}_{ij}, u_j) = F(\overline{\beta' x_i} + u_j) \qquad (2)$$

where F is the cumulative distribution function (cdf) of the individual specific error term ε_{ij} that maps $(\overline{\beta' x_i} + u_j)$ into the (0;1) range. In order to get consistent estimates for β in (2), it is necessary to eliminate the unobserved market-specific effects u_j from the equation. Following Chamberlain (1980), the solution to this problem lies in specifying F as the logistic cdf and writing the likelihood function based on the conditional distribution of the data, conditioned on a set of sufficient statistics for u_j. By definition of a sufficient statistic, the distribution of the data given this sufficient statistic will not depend on u_j anymore.

Chamberlain (1980) showed that a sufficient statistic for u_j is $\sum_j y_{ij}$ and that the conditional log-likelihood function will only depend on β, $\bar{x}_{ij}$, and y_{ij}:

$$\ell_i = \sum_i \ln[\exp(\bar{\beta}' \sum_j \bar{x}_{ij} y_{ij}) / \sum_{d \in B_i} \exp(\bar{\beta}' \sum_j \bar{x}_{ij} d_j)] \qquad (3)$$

where

$$B_i = \left\{ d = (d_1, ..., d_J) \mid d_j = 0 \text{ or } 1 \text{ and } \sum_j d_j = \sum_j y_{ij} \right\}$$

The estimator only considers groups where at least one firm observes a positive outcome because the individual likelihood contribution of a firm from a group j with no single positive observation is zero according to (3). The sample log-likelihood summed across i can be used to obtain a $\sqrt{N}$-asymptotically normal estimator of β, and all inference follows directly from conditional MLE theory (Wooldridge, 2002). Thus, by conditioning the log-likelihood function on $\sum_j y_{ij}$, the u_j are swept away and a consistent estimator is obtained that does not place any restrictions on the distribution or co-variance of the unobservable group-specific effect. Solution (3) critically depends on choosing F to be the logistic cdf, a similar simplification for probit models has not yet been found (Baltagi, 2001).

DATA

The dataset used for this study originates from the Nov/Dec 2003 enterprise survey of the e-Business Market W@tch, a large scale observatory initiative that is sponsored by the European Commission, DG Enterprise and Industry. The e-Business Market W@tch monitors the adoption, development and impact of electronic business practices in different sectors of the European economy. The initiative was launched in late 2001 with the purpose to provide reliable and methodically consistent empirical information about the extent, scope, and factors affecting the speed of e-business development at the sector level in an internationally comparative framework, information which was previously not available from other sources such

as the official register-based statistics or market research studies. [1] The e-Business Market W@tch database is widely accepted and has been used by various official institutions, including the European Commission and the OECD (2004).

For the Nov/Dec 2003 survey, participants were randomly selected from 10 sectors and 25 European countries, but not all sectors were covered in each country. Table A1 in the Annex shows the definition of the sectors included in the study, Table A2 provides the numbers of successfully completed interviews in each country-sector cell.

The number of enterprises sampled in each country-sector cell was large enough to be approximately representative of the underlying population. The economic conditions within each sector can be very different depending on the country. In addition, market structures and the economic conditions can vary greatly between the sectors of each country. However, the economic conditions for firms operating in the same country and the same sector can be assumed to be reasonably comparable. In the dataset, each firm belongs unambiguously to a specific country-sector group of enterprises, which defines the relevant market in this study. Overall, the sample contains 101 markets (the market index in the regression model is defined as $j = 1,...,101$). On average, there are approximately 60 firms surveyed per market and a total of 7,302 firms.

The dataset contains qualitative information about firm performance. In particular, firms were asked the following questions relating to their performance:

- Has your company been profitable over the past 12 months? (yes / no / don't know, not applicable)
- Has the turnover of your company increased, decreased or roughly stayed the same when comparing the last financial year with the year before? (increased / decreased / roughly stayed the same / don't know, not applicable)
- Has the number of employees in your company increased, decreased, or roughly stayed the same during the past 12 months? (increased / decreased / roughly stayed the same / don't know)

[1] Further information about the project can be found at http://www.ebusiness-watch.org.

Based on these questions, seven binary performance variables were computed that serve as dependent variables in the analysis[2]. In this study, all seven binary variables are analyzed in separate regression models. This allows to get detailed insides into the effects of different kinds of innovation and technological development status on financial performance, employment effects, and firm growth. All models follow the same basic structure, they are only different in the dependent variable.

The advantage of this type of qualitative data is that it provides information about dynamic developments which are independent of the size of each firm, although only one cross-section is observed. Information about absolute turnovers and the number of employees in the survey are only useful to identify the size of a firm, but they do not provide any information about dynamic developments and performance if no true panel data are available. Alternatively, one could survey firms about the absolute size of changes (Δ_t), but such detailed information are usually not obtainable in telephone interviews.

In addition to the above questions that relate to the performance of enterprises, the survey also contained questions that relate to different kinds of innovative activities of firms. In particular, the following two questions were asked:

- Has your company introduced new or substantially improved products or services to your customers during the past 12 months? (yes / no / don't know, not applicable)
- Has your company introduced new company internal processes during the past 12 months? (yes / no / don't know, not applicable)

A particular goal of the survey was to find out the current importance of Internet-based technology for innovative activity. Therefore, a follow up question was asked to companies that said "yes" to the first innovation question:

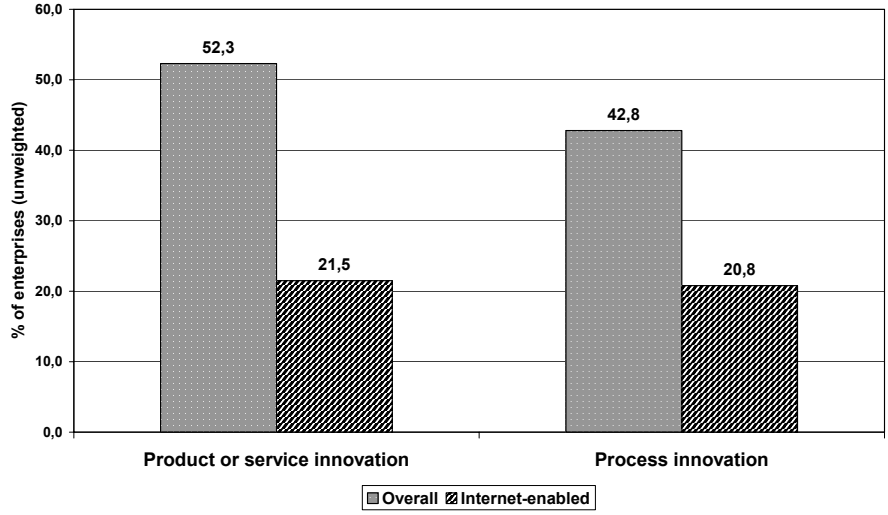
- Have any of your product / service innovations over the past 12 months been directly related to or enabled by Internet-based technology? (yes / no / don't know, not applicable)

[2] Observations with missing values or subjects answering „don't know, not applicable" were dropped from the analysis. This amounts to 14.4% of the sample for turnover development, 11.8% for profitability, and 1.2% for employment development.

- Have any of your company internal process innovations been directly related to or enabled by Internet-based technology? (yes / no / don't know, not applicable)

96% of the survey respondents (N = 7,302) provided valid responses on the product / service innovation questions, and 96.5% on the process innovation questions. The relative frequencies of these questions are displayed in Figure 1.

Figure 1: Innovative activities of companies 2002-2003



Note: Unweighted survey results, e-Business Market W@tch Nov/Dec 2003

52.3% of enterprises in the sample introduced substantially improved products or services to their customers in 2003. 41.1% of these firms report that they have used Internet-based technologies to enable product or service innovations. This corresponds to 21.5% of enterprises in the sample in 2003. The importance of IT and the Internet is even more pronounced for process innovations: 42.8% of enterprises say that they introduced new internal processes in 2003. About one half of these firms state that Internet-based technologies have been related to or directly enabled their process innovations.

Thus, it can be concluded that a substantial amount of innovative activity in the European Union was related to or enabled by IT and Internet-based technologies in 2003.

Another interesting finding is reported in Table 2: There is a strong significant positive correlation between product innovations and process innovations that are Internet-related. Similarly, non-Internet-enabled product and process innovations are also positively correlated at a

high level of significance. On the other hand, Internet-enabled innovations are negatively associated with non-Internet-related innovations. Hence, it appears that there are three clusters of firms: Those that use IT and the Internet extensively to conduct both product/service and internal innovations, and those that also innovate in both domains, but without using the Internet. The third cluster of firms comprises of firms that do not innovate or only innovate in one domain. The correlations suggest that companies could be on different technological trajectories, either relying extensively on IT to conduct innovation, or not.

Table 2: Pearson correlations of innovative activity indicators

	Product innovation – general	Product innovation – Internet enabled
Process innovation - general	0.2897**	-0.1190**
Process innovation - Internet enabled	-0.1730**	0.4858**
N = 6,879. e-Business Market W@tch Nov/Dec 2003. ** denotes significance at the 99% confidence level.		

Table 3 shows the descriptive summary statistics for the dependent variables. 44.3% of enterprises in the sample experienced increasing turnover from 2002-2003, 82% report profitability for this period, and 23.3% report increasing employment. Less than one fifth of the sample recorded decreasing turnover, decreasing employment or no profits.

Table 3: Performance indicators of companies 2002-2003

	Relative frequency	N
Turnover: comparison last financial year with year before		
increased	44.3%	6,253
decreased	20.4%	
roughly stayed the same	35.3%	
Has your company been profitable over the last 12 month?		
yes	82%	6,443
No. of employees: comparison last financial year with year before		
increased	23.2%	7,218
decreased	17.5%	
roughly stayed the same	59.3%	
Note: Unweighted survey results from Nov/Dec 2003.		

Table 4 shows correlation coefficients of the performance indicators. Not surprisingly, we find that firms that experience turnover growth are significantly more likely to be profitable

and to increase employment and vice versa. Noticeably, the development of turnover and employment are measures indicating whether a company is growing, declining, or stagnating. According to Table 4, growth is positively related to profitability, however it is not a pre-requisite of profitability. A significant proportion of firms in the sample are profitable although they did not increase employment. Also, some firms (not a significant part) are profitable although they experienced a decline.

Table 4: Pearson correlations of performance indicators

	Profit	Employment (increase)	Employment (unchanged)	Employment (decrease)
Turnover (increase)	0.2215* (N=5,887)	0.3439* (N=6,226)	-0.1239* (N=6,226)	-0.2144* (N=6,226)
Turnover (unchanged)	0.007 (N=5,887)	-0.1886* (N=6,226)	0.1940* (N=6,226)	-0.0425* (N=6,226)
Turnover (decreased)	-0.2825* (N=5,887)	-0.2001* (N=6,226)	-0.0776 (N=6,226)	0.3147* (N=6,226)
Profit				
Employment (increase)	0.1126* (N=6,408)			
Employment (unchanged)	0.0894* (N=6,408)			
Employment (decrease)	-0.2391* (N=6,408)			
e-Business Market W@tch Nov/Dec 2003. * denotes significance at the 99% confidence level.				

REGRESSION RESULTS

The error component model of (7.3) was estimated using the e-Business Market W@tch data. Table 5 reports the regression results for turnover development. Table 6 shows the results for profit and employment development.

Table 5: Fixed effect logistic regression results on turnover development

Co-variables	*Turnover increase*	*Turnover unchanged*	*Turnover decreased*
Product or service innovations last year:			
Internet-related	0.402**	-0.205*	-0.293**
general	0.439**	-0.280**	-0.219**
Internal process innovations last year:			
Internet-related	0.395**	-0.342**	-0.136
general	0.331**	-0.219**	-0.181
10-49 empl.	0.257**	-0.024	-0.307**
50-249 empl.	0.274**	0.127	-0.592**
>250 empl.	0.409**	-0.196	-0.347*
Market share:			
< 1%	-0.294**	-0.128	0.502**
1%-5%	-0.059	-0.153	0.285*
6%-10%	0.233*	-0.061	-0.283
11%-25%	0.122	-0.077	-0.071
> 25%	0.144	-0.092	-0.087
% empl. w. university degree	0.001	0.001	-0.002
# e-business technologies	0.152**	-0.125**	-0.064
Model diagnostics			
N obs	5,697	5,697	5,697
N groups	101	101	101
Log-likelihood	-3,355	-3,328	-2,453
Sign. (Prob>chi2)	0.000	0.000	0.000
** denotes significance at the 95% confidence level, * denotes significance at 90% confidence. Reference categories: no innovations last year, 1-9 empl., market share unknown			

Table 6: Fixed effect logistic regression results on profit and employment development

Co-variables	*Profit*	*Employment increase*	*Employment unchanged*	*Employment decreased*
Product or service innovations last year:				
Internet-related	0.351**	0.409**	-0.196*	-0.165
general	0.238**	0.379**	-0.155*	-0.171*
Internal process innovations last year:				
Internet-related	0.026	0.579**	-0.400**	-0.093
general	0.048	0.495**	-0.402**	0.063
10-49 empl.	0.046	0.885**	-0.726**	0.228**
50-249 empl.	-0.079	0.876**	-0.881**	0.495**
>250 empl.	-0.097	0.860**	-1.241**	0.988**
Market share:				
< 1%	-0.536**	-0.098	-0.198*	0.388**
1%-5%	-0.039	-0.026	-0.157	0.274*
6%-10%	-0.007	0.172	-0.201	0.126
11%-25%	0.347*	0.319**	-0.350**	0.172
> 25%	0.229*	0.075	-0.100	0.083
% empl. w. university degree	0.000	0.001	0.000	-0.001
# e-business technologies	0.033	0.034	-0.085**	0.081*
Model diagnostics				
N obs	5,796	6,415	6,415	6,415
N groups	100	101	101	101
Log-likelihood	-2,320	-2,905	-3,783	-2,586
Sign. (Prob>chi2)	0.000	0.000	0.000	0.000
** denotes significance at the 95% confidence level, * denotes significance at 90% confidence. Reference categories: no innovations last year, 1-9 empl., market share unknown				

The regression results indicate that all four kinds of innovation are positively associated with turnover and employment growth and negatively associated with stagnating turnover and employment development. This supports the findings of earlier studies, which stated that innovators are more likely to grow (Audretsch 1995, Mansfield 1968), independent from their ability to achieve excess profits. Also, this supports the finding that firms innovating in products, but also in processes, are more likely to expand their employment than non-innovative firms, because they grow faster in their respective markets (Pianta 2004, Pasinetti 1981).

However, there are also some differences between product and process innovations: While product innovations are positively associated with profitability, internal process innovations do not show a significant interrelation with profits. This holds for both IT- and non-IT-enabled process innovations. Also, product innovations are negatively associated with decreasing turnover and non-Internet-enabled product innovations are negatively associated

with decreasing employment. Thus, firms that conduct product or service innovations are less likely to be in the group of firms experiencing decline. However, this does not hold for internal process innovations. Enterprises engaged in improving internal processes are not less likely to exhibit decreasing employment or turnover levels. This corresponds with the view that process innovations are a defensive strategy, aimed at defending or increasing market shares in existing markets; whereas product innovations are an offensive, growth-oriented strategy that aims at entering new markets. Also, it implies that process innovations are more likely to have a labor-substituting effect at the firm level than product innovations, i.e., firms facing decline might invest into a labor-saving process innovation to reduce costs.

An interesting finding is that differentiating between Internet- and non-Internet related innovations reveals only small differences in estimated coefficients, i.e. whether firms use the Internet or not to conduct innovations is less important than whether they innovate at all. Also, the differences between process- and product-innovations are greater than the differences between Internet- and non-Internet related innovations.

In addition, it is interesting to observe that firms being more advanced in the use of IT (i.e. firms having adopted a higher number of Internet-based technologies) have a greater chance to exhibit increasing turnover. However, no significant effect can be reported for profitability. And, firms that are endowed with a higher number of e-business technologies show a higher chance of being in the group of firms that decrease employment, suggesting that IT might – after all – have a labor substituting effect.

The results also support standard economic predictions: Small firms with little market share are less likely to be profitable, and they are also less likely to exhibit increasing turnovers. On the other hand, firms with high market shares are significantly more likely to be profitable, suggesting that they can exploit a certain degree of market and price setting power. Firms with low market shares have a higher chance to exhibit shrinkage in turnover and employment development, suggesting a decline of enterprises which were not able to capture larger shares of their respective markets.

In all regressions, the proxy variable for human resources (% of employees with a university degree) did not turn out to be significant, possibly suggesting that it was an improper proxy to measure the relevant types of human resources required in different kinds of firms.

DISCUSSION

There are five key messages arising from the empirical analysis:

1. Internet-based technologies are currently important enablers of innovation.
2. All four types of innovation are positively associated with turnover and employment growth at the firm level.
3. Only product/service innovations are positively associated with profitability. Process innovations do not show significant interrelation with profits.
4. Internet-enabled innovations are at the very least not "inferior" to other kinds of innovations in terms of positive correlation with performance indicators.
5. More important than the technologies themselves (the number of e-business technologies they have installed) is what firms do with them (whether they are used to conduct innovations or not).

Although the direction of the causality between innovative activities and performance is ambiguous, it may appear surprising to find that only product/service innovations are positively associated with profitability, while process innovations are not. However, the results can be rationalized, assuming that performance is caused by innovation: A simple explanation could be that process innovations take longer to generate positive returns than product innovations. Process innovations are organizationally embedded and have to be routinized. Such lagged effects are obviously not observable in this cross-sectional dataset. Also, process innovation might be interdependent with other technologies and firm-specific resources and may therefore not yield optimal returns if those complementary assets are not available or not advanced enough.

In addition, from a theoretical point of view it can be argued that strategic advantages of conducting process innovations are only sustainable (thus leading to excess profits) if direct rivals have not imitated the innovation yet (Reinganum 1981b, Götz 1999, Stoneman and Kwon 1995). According to this view, the adoption of generic "best practice" solutions or technologies, often suggested by process re-engineering consultants and standard business software

packages, generate only temporary excess returns at best, as long as competitors do not successfully copy the same practice. To a certain extent, the invention and implementation of a "best practice" solutions bears the public good problem of information: A "best practice" or standardized technological solution may be non-rivalrous in the sense that its invention and use by one firm does not automatically preclude the use by another. It may also be non-excludable if the producer of the new knowledge is unable to effectively prevent non-payers from using it. Thus, a successful process innovator may involuntarily create a positive externality for the market without being able to get a private benefit from the investment. Such externalities might be desirable from a social welfare or public policy point of view, but their existence limits the incentives of firms to invest in such activities. This theoretical appropriability problem is alleviated if the costs of conducting the process innovation or implementing the new technology is not zero, if the process and the associated technology is complex, and if it relates to other complementary or specialized assets of the firm that cannot be easily copied by rivals (Geroski 1995). Thus, sustainable advantages arising from process innovations and new production technologies can only be achieved if the innovation cannot be perfectly copied by rivals. Note that this argument does not only apply to IT-based process innovations, but to process innovations in general.

The public good problem of innovation, and hence the associated appropriability problems are not as severe for product/service innovations than for process innovations. Naturally, it is much easier to claim property rights and charge for an innovation if it can be embodied in an output sold as a new product or service. Often, products or services can be differentiated vis-à-vis competitors offers, making perfect imitation less likely and hence increasing the chance of appropriating private returns from the investment. The empirical result that product innovations are positively associated with profitability, but process innovations are not could suggest that the firms included in this sample are more successful in differentiating their products and services than their production processes. Yet, the successful diffusion of a new "best practice" in an industry may still lead to higher productivity in the firms adopting the "best practice", which in turn increases their chance of survival in the market. The successful adoption of a "best practice" or process technology leads to lower production costs of the more productive firms, which makes it optimal for them to increase their output levels at a given market price. Thus, this process leads to growth of the process innovating firms and the entire industry.

However, as more industry players imitate the new process and output grows, the equilibrium price in the market will fall, to the benefit of consumers and social welfare (Reinganum 1981b, Götz 1999). Via this mechanism, consumers might be the actual winners of widespread process innovations within an industry. The empirical evidence presented in this study is consistent with this theory.

From this perspective, the results suggest that adopting generic "best practice" solutions, often associated with standard business software and process re-engineering, do at best generate temporary excess returns, as long as competitors do not successfully copy the same practice. This suggests that sustainable advantages that are due to IT can only be achieved in two ways: (1) if the technology triggering a process innovation can be customized, complementing some other scarce resource of the firm, thus limiting imitation; or (2) if the technology can be used to innovate a new product or service offer that is valuable to customers and cannot be perfectly copied by competitors. In addition and independent from the ability to exclude imitation, firms may achieve temporary performance advantages vis-à-vis competitors, as long as competitors have not yet copied the innovation. Provided that technological uncertainty is not too large, this suggests that early adoption of IT can provide first mover advantages.

Assuming a reverse causality, i.e. if innovation follows performance and not the other way around, the empirical results also have an interesting interpretation: It would suggest that profitable firms are more likely to invest in product than in process innovation, which would imply that profitable firms are more customer oriented, focusing on new products and services to satisfy customer needs rather than on cost leadership.

In any case, the results emphasize the strategic importance of information technology. IT matters because it is an important enabler of innovation. Information technology and e-business tools in particular enable process innovations, if the implementation of the new technology succeeds, the routines are changed, and the new system is actually utilized. Also, IT and e-business tools can enable product or service innovations, if the new technology is successfully used to offer a new service or deliver products to customers in a way that is new to the enterprise. Depending on how the new technologies are used, the strategic objectives and consequences of IT can be quite different: The primary objective of process innovations is to reduce costs for a given output, i.e. to improve productivity, involving appropriability problems if the same process and the same technology can be perfectly copied by rivals. Yet, even

in the case that firms cannot gain excess profits from their IT-enabled process innovation, increased efficiency often leads to growth and higher chances of survival in a given market, which can also be a strategic objective. On the other side, if IT is used to create new product and service offers, the strategic objective can be to explore new markets and to differentiate services and delivery modes from competitors, which can result in sustainable advantages. Especially this last point is often overlooked in the discussion about the relevance of IT, though this study demonstrates the empirical relevance of IT as an enabler of product and service innovations.

However, once the innovative potentials of IT in general and Internet-based technologies in particular will be exhausted, further investments will lose their strategic relevance and IT will become an infrastructure like streets or railways, just like Nicolas Carr (2003) suggested. However, according to the evidence presented here, which is based on 2003 data, we are still far away from such a point. Also, the development of new IT applications for business purposes is still thriving. This suggests that IT will maintain its strategic importance, simply because new IT applications will facilitate further process and product/service innovations among the adopters of these new technologies. Yet, the ability of firms to successfully transfer IT into innovation is still not a sufficient condition for superior performance and sustainable competitive advantage because performance also depends on the behavior of customers and competitors. However, the results of this study suggest that firms using IT to innovate are – at the very least – not less successful than firms using other ways to innovate. Also, innovative firms in our sample are clearly more likely to be successful than non-innovative firms.

Limitations

It should be recalled that appropriability methods vary greatly in their kind and effectiveness among industries (Levin et al. 1987, Cohen et al. 2000). Thus, the empirical results of this study with respect to profitability could be sensitive to the industries included in the sample. Consequently, the result of this study that process innovation (whether IT-enabled or not) does not correspond to higher profitability should not be generalized.

Furthermore, although the data used for this analysis are unique and interesting in various

ways, they also have shortcomings. Obviously, it would be desirable to have panel data to observe the causality of innovation on firm performance, as well as the effects of past performance and other lagged variables. In addition, panel data would enable to control for unobserved heterogeneity at the firm level. Also, quantitative instead of qualitative performance variables would be desirable because they contain a greater amount of information. In addition, given that the data were collected via computer-aided telephone interviews with firm executives and IT managers, one might question the precision of their answers, especially with regard to financial performance measures. Yet, as long as the potential imprecision of their answers is not systematically related with the explanatory variables, the direction of the regression results will remain unaffected. For most variables, this seems to be a plausible assumption. However, there is one exception: It could be argued that the profitability variable in this dataset is not an objective variable (indicating whether a firm has made a positive profit in the last financial year), but a subjective variable, measuring the profit of a firm vis-à-vis some aspiration level that depends on past performance. For example, firms that experience growth could have higher aspiration levels regarding their profits than firms that experience a decline. Thus, it could be that some firms that were actually objectively profitable did not report it as such and vice versa, because they were making reference to their aspiration levels, which are unobservable in the data. If past growth is positively associated with current growth and innovative activities, and also with higher aspiration levels for profitability, the results could be biased, underestimating the positive relation between innovative activity and profitability. Thus, if such a bias exists indeed, the main messages of this study would be unaffected, with the possible exceptions that a significant positive relation between process innovation and profitability might exist after all.

Conclusion

This study emphasizes the strategic importance of IT, arguing that IT matters as a potential source of sustainable competitive advantage because it enables innovation. It eliminates a gap in the literature by explicitly analyzing the relationship between different kinds of innovations with performance variables and by comparing IT- and non-IT-based innovations. Using a very large sample of enterprises in Europe surveyed in Nov/Dec 2003, it is shown that a sub-

stantial number of firms currently use IT to conduct process or product/service innovations. The regression results show that innovative firms in the sample are more likely to grow. This should enable firms to increase their market share in existing markets and increase their probability of survival. In addition, firms conducting product or service innovations are also more likely to be profitable. In general, whether and how firms innovate turns out to be of greater importance than whether firms rely on IT to conduct innovation or not. This suggests that IT is a specific way to improve processes or to introduce specific kinds of product and service innovations, but certainly not the only one. Yet, as long as there continuous to be rapid improvements in IT and as long as useful new IT applications are being developed, IT will remain its strategic importance.

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ANNEX – Data description

Table A1 - Sector definition of e-Business W@tch survey Nov/Dec 2003

	Sector short name	NACE Rev. 1 Codes
01	Textile	17 – Manufacture of textile and textile products 18.1 – Manufacture of leather clothes 18.2 – Manufacture of other wearing apparel and accessories 19.3 Manufacture of footwear
02	Chemicals	24 – Manufacture of chemicals, chemical products and man-made fibers 25 – Manufacture of rubber and plastic products
03	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
04	Transport Equipment	34 – Manufacture of motor vehicles, trailers and semi-trailers 35 – Manufacture of other transport equipment
05	Crafts & trade	17 – Manufacture of textiles and textile products 18.1-2 – Manufacture of wearing apparel and dressing 19.3 – Manufacture of leather and leather products (footwear only) 30 – Manufacture of office machinery and computers 31.1-2 – Manufacture of electrical machinery and apparatus 32 – Manufacture of radio, television and communication equipment and apparatus 34 – Manufacture of motor vehicles, trailers and semi-trailers 35 – Manufacture of other transport equipment 20 – Manufacture of wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials 36.1 – Manufacture of furniture 45.2-4 – Construction (Building of complete constructions, building installation and completion)
06	Retail	52.11 – Retail sale in non-specialized stores with food, beverages or tobacco predominating 52.12 – Other retail sales in non-specialized stores 52.4 – Other retail sale of new goods in specialized stores, except of motor vehicles and motorcycles
07	Tourism	*55 – Hotels and restaurants* 62.1 – Scheduled air transport 63.3 – Activities of travel agencies and tour operators; tourist assistance activities n.e.c. 92.33 – Fair and amusement park activities 92.52 – Museum activities and preservation of historical sites and buildings 92.53 – Botanical and zoological gardens and nature reserve activities
08	ICT Services	64.2 - Telecommunications 72 – Computer-related activities
09	Health Services	85.1 – Health activities 85.3 – Social work activities

10	Business Services	74.1 – Legal, accounting, book-keeping and auditing activities; tax consultancy; market research and public opinion polling, business and management consultancy; holdings 74.2 – Architectural and engineering activities and related technical consultancy 74.3 – Technical testing and analysis 74.4 – Advertising 74.5 – Labor recruitment and provision of personnel 74.6 – Investigation and security activities 74.7 – Industrial cleaning 74.8 – Miscellaneous

Table A2 - Country-sector coverage e-Business W@tch survey Nov/Dec 2003

	Sector									
Country	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**
A				68			132		100	
B		101				100				100
DK						67	67		66	
FIN										
F	100				101				100	100
D	100				100				100	100
GR	84		76	89	75		75			
IRL		70					70	71		
I	100				100				100	101
NL	100							101	102	
P				104		100				100
E	101				108				101	100
FIN	75		75					76		
S		80	75	79						80
UK	100				100				100	100
CY						64				
CZ		60		60			60	60	60	
EST	50	50	50	21	65	50	50	50	50	50
H			80	80						80
LT						57				
LV	51	49				51				
M							51			
PL	80	80	80	80	80	80	80	80	80	80
SLO			56				51	53	55	58
SK	50		50			50				60
N	30					70				

Note: Table shows number of successfully completed interviews, country names abbreviated by their international license plate codes