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PRODUCTIVITY EFFECTS OF ICT IN FINNISH BUSINESS***

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*** This report concludes the first preliminary phase of *The economic effects of information and communication technology* research project (9/430/2002) initiated by Tero Kuitunen at *The Ministry of Trade and Industry* of Finland and conducted by Mika Maliranta at *Statistics Finland* and Petri Rouvinen at *Etlatieto Oy*.

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ABSTRACT: This report concludes the first phase of *The economic effects of information and communication technology* research project. Its primary objectives were to compile the necessary data, establish research links, and conduct preliminary analysis.

The findings show that widespread use of ICT is indeed quite recent. Contrary to what was believed in the midst of the 'new economy' boom, the increasing use of ICT is primarily a 'within firms' phenomenon, *i.e.*, the contribution of restructuring to the observed changes in the aggregate ICT-intensity is rather marginal. Decompositions nevertheless suggest that experimentation and selection are quite intense among young ICT-intensive firms.

After controlling for industry and time effects as well as labor and other firm-level characteristics, the excess productivity of ICT-equipped labor ranges from eight to eighteen per cent. The effect is *manifold* in younger firms and in ICT-providing branches. The finding with respect to firm age is consistent with the need of ICT-complementing organizational changes. The finding on ICT-providing branches is *not* driven by the communications equipment industry but rather by ICT services. Overall, the ICT-induced excess productivity seems to be somewhat higher in services than in manufacturing. Manufacturing firms benefit in particular from ICT-induced efficiency in *internal* whereas service firms benefit form efficiency in *external* communication. We find weak evidence for the complementary of ICT and education.

KEYWORDS: Productivity, information and communication technology, ICT, new economy.

MALIRANTA, MIKA; ROUVINEN, PETRI. *Tieto- ja viestintäteknologian vaikutukset suomalaisessa liike-elämässä*. Helsinki: ETLA, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 2003, 42 s. (Keskusteluaiheita – Discussion Papers, ISSN 0781–6847, No. 852).

TIIVISTELMÄ: Tämän raportin myötä päättyy *Tieto- ja viestintäteknologian talousvaikutukset* -hankkeen esitutkimusvaihe, jonka tavoitteina olivat ICT-tutkimusta tukevien aineistojen ja tutkimusyhteyksien luonti sekä alustava tilastollinen ja ekonometrinen analyysi.

ICT laajamittainen käyttö suomalaisyrityksissä on suhteellisen uusi ilmiö. Toisin kun "uuden talouden" huumassa uskottiin, koko talouden tasolla havaittavaa ICT:n yleistymistä ajaa yritysten sisällä tapahtuva kehitys, ei niinkään rakennemuutos eli ICT-intensiivisten yritysten (synty ja) potentiaalisesti ripeämpi kasvu. Näyttäisi kuitenkin siltä, että sinänsä rakennemuutos – kokeilu, valikoituminen ja "luova tuho" – nuorten ICT-intensiivisten yritysten keskuudessa on voimakasta.

Kun toimiala-, suhdannesykli- ja yrityskohtaisten tekijöiden (mm. osaamistaso ja pääomakanta) vaikutus huomioidaan, ICT parantaa työntekijän tuottavuutta kahdeksasta kahdeksaantoista prosenttia. Tuottavuusvaikutus on moninkertainen uudemmissa yrityksissä. Tämä löydös viittaa täydentävien organisatoristen innovaatioiden merkitykseen tuottavuusvaikutusten aikaansaamiseksi. ICT:tä tuottavat alat näyttävät olevan selvästi parempia myös ICT:n hyödyntämisessä, eikä tämä löydös liity viestintävälinevalmistukseen eikä myöskään ao. alojen yleisesti ottaen korkeaan tuottavuuteen ja sen ripeään kasvuun. Vaikutukset palveluissa ovat teollisuutta suurempia. Teollisuusyritykset hyötyvät enemmän *sisäisiä* ja palveluyritykset *ulkoisia* tietovirtoja tehostavista teknologioista.

AVAINSANAT: Tuottavuus, tieto- ja viestintäteknologia, ICT, uusi talous.

TABLE OF CONTENTS

PREFACE

Several macro-level studies have highlighted the important role of information and communication technologies (ICTs) in the Finnish economy (see, e.g., Jalava, 2002; Jalava & Pohjola, 2002; Koski, Rouvinen, & Ylä-Anttila, 2001, 2002b). They provide interesting insights on the matter. Technological change and its possible productivity effects nevertheless take place at the micro-level and should thus also be studied at relatively low levels of aggregation. In order to facilitate such research in Finland, Tero Kuitunen at *The Ministry of Trade and Industry* initiated a research project on *The economic effects of information and communication technology* (9/430/2002).

In the fall of 2002 *Etlatieto Oy* and *Statistics Finland* were commissioned to carry out the **first** preliminary phase of the research, with the primary objectives of compiling the necessary data, establishing research links, and conducting preliminary analysis. The potential and need as well as the final outline of the **second** phase of more in-depth analysis will be evaluated and framed based on the reactions on the outcomes of this first phase.

This report documents and uses the data sets compiled, which are now available at Statistics Finland's research laboratory for those interested. *The Confederation of Finnish Industry and Employers* (TT) has graciously made some of its ICT-related data available to the researchers, which has been exploited in a separate report (Tsupari & Rouvinen, 2002).

The representatives of the project have also participated in the OECD *ICT and business performance* work coordinated by Dirk Pilat. Some findings of the project have already been discussed in the Stockholm, London, and Paris meetings of the OECD group, at the 26th CIRET Conference in Taipei, during the Finland visit of the UK Department of Trade and Industry e-business policy team, at the first WIFO workshop on European Competitiveness Report 2003 in Vienna, at the annual meeting of the Employers' Confederation of Service Industries in Kouvola, and during the OECD economists' visit at the Ministry of Trade and Industry in Helsinki.

Although this report already includes a number of interesting results, it merely scratches the surface of the extremely rich data. Besides the ones reported here, the researchers have followed, although not developed to their final form, more than a dozen of research leads upon exploring the data. Some of these are discussed and proposed as avenues for further research in the concluding section.

Helsinki, May 2003,

Mika Maliranta and Petri Rouvinen.

1. INTRODUCTION

1.1. BACKDROP – THE END OF THE NEW ECONOMY

In the mid-1990s *Business Week* coined the term 'new economy' to characterize the long boom and increasing technology-intensity in the U.S. economy. In the late 1990s the term became synonymous with bullish stock markets and incredible riches the dotcom-entrepreneurs created out of thin air.

Now, after the bust of the stock market, many new economy companies and associated assets are valued at less than one per cent of their peaks. While for some the new economy went down as the virtual wealth evaporated, it is also widely believed that *digital* information and communication technologies, ICTs, have indeed induced a new techno-economic paradigm or the third industrial revolution, not unlike steam-power and electricity at their times.

Fundamentally the new economy may be characterized as an information revolution. People work increasingly with their brains rather than with their hands and ICT provides the 'tools for thought'. Since ICT is a 'general-purpose technology' (Bresnahan & Trajtenberg, 1995) having a wide range of applications at virtually all walks of life, its effects on the society at large are profound. Quah (1999) coins the term 'weightless economy', recognizing the fact that our economic wealth is increasingly in intangible assets, *i.e.*, in usable strings of knowledge, such as software, digital content, patents and other intellectual property rights, DNA profiles, business concepts, *etc.*

Invention of the transistor (*Bell Labs*, 1947) and the integrated circuit (*Texas Instruments*, 1958) as well advances in fiber optical cables (*Kao & Hockham*, 1966) laid the technical foundations for ICT, as we know it today. They have led to the rapid and continuous declines in the quality-adjusted real prices of both processing power and especially data transmission capacity.

So far the ICT-induced changes have been the most prominent in the sectors providing ICT goods and services as well as in digital content provision. But since the most fundamental long-run effects of ICT relate to the way we acquire, generate, store, transmit and exploit information (digitally coded knowledge), *all* sectors will be affected.

It is perhaps good that the term 'new economy' has been downgraded. The current state of development is about the 'old' or, more precisely, about the 'whole' economy. The introduction of ICT is comparable to that of electricity roughly a century ago. It is a major discontinuity in the technological evolution. Countries, industries, firms, and individuals that adopt sooner rather than later should prosper relative to the others.

1.2. CONTEXT – ICT IN FINLAND

The consequences of the rising importance of ICT have been particularly pronounced in Finland. Koski, Rouvinen and Ylä-Anttila (2002a) show that in a decade the country went from being one of the least ICT-specialized industrialized countries to become the most specialized one. The Finnish ICT cluster (see Paija, 2001) is heavily specialized in communications technology production dominated by *Nokia*, although the cluster comprises of several thousand firms, including over three hundred first-tier suppliers of *Nokia* (see Ali-Yrkkö, 2001).

There is some indication that as a *user* of ICT Finland may not be as exceptional as it is as a *producer*. Studies at the macro level show that, while overall effects of ICT are quite large in Finland, they are mostly mediated *via* ICT provision (Jalava & Pohjola, 2002). While penetration rates of ICT are typically quite high, the actual usage of the available infrastructure is less so (Rouvinen, 2002a). Obviously the interest is on the *benefits* of ICT use – something that is not captured very well in the current literature.

The Finnish economy has experienced a great leap in its productivity since the late 1980s, largely attributable to advances in the manufacturing sector. Analysis with plant-level data has shown that the acceleration in productivity has largely taken place through micro-level restructuring between plants but within industries (see Maliranta, 2002). These findings underline the importance of firm (and plant) demographics in the productivity evolution and are in accordance with the propositions of various firm life-cycle models (see Ericson & Pakes, 1995; Jovanovic, 1982). These models bring the process of incessant experimentation and selection in the markets into the core of the long-run economic development. While the productivity-enhancing plant-level restructuring seems to have taken off as early as in the late 1980s, it is unclear to what extent these developments can be attributed to ICT. Various other profound changes in the economic environment since 1980s have probably contributed to the process and paved the road for ICT and its productivity effects in the 1990s.

1.3. OBJECTIVES AND STRUCTURE

In what follows, we primarily study the productivity effects of ICT at the level of a firm. We address the following set of questions:

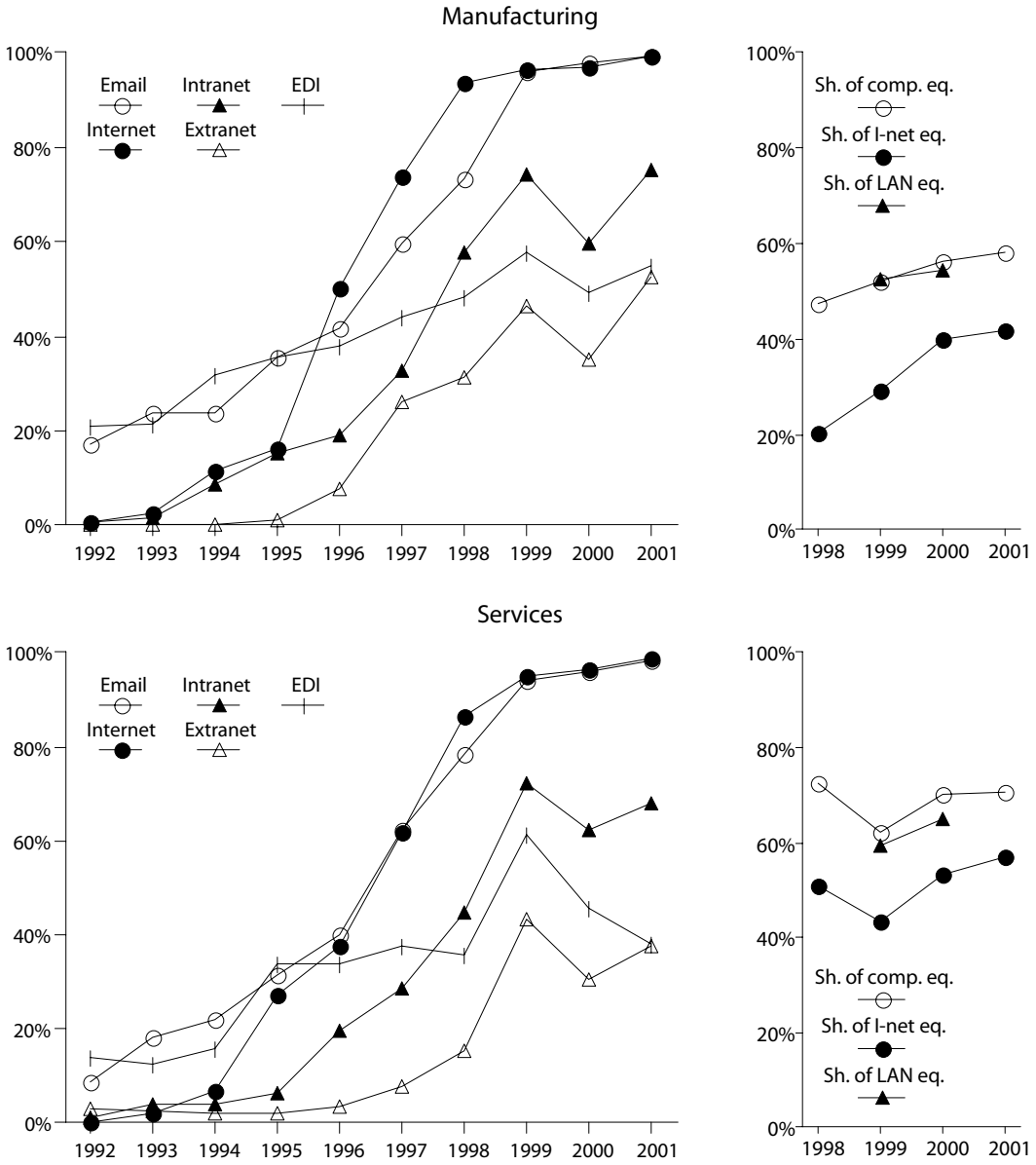
- Does ICT have measurable effects on productivity,
- If so, does the role of ICT differ in manufacturing and services and/or in ICT and non-ICT industries,
- Does the potency of ICT vary by firm age,
- Does the potency of ICT vary across time,
- Is ICT complementary to education, and
- What are the effects of various technologies (computers, Internet, local area networks).

This introductory part is followed by Section 2 discussion of some of the developments in workers' ICT usage. Section 3 performs a principal components and decomposition analysis. Section 4 provides a brief theoretical background and review of previous literature and then provides the estimation results of the derived model. Section 5 concludes.

2. Increase in workers' ICT usage

One of the key questions of the study at hand is, how much the productivity of Finnish businesses is boosted by having a greater share of ICT-equipped labor, *i.e.*, workers that use a computer, Internet, and/or local area network (LAN) at work. In order to answer this question, we first look at the increases in ICT use in recent years.

Figure 1. Firm (left panes) and employment (right panes) exposure to various forms of ICT in Finnish manufacturing and services (probability and employment weighted).



Data source: Statistics Finland's *Internet use and e-commerce in enterprises* surveys. The shares of firms and employees are calculated by using employment and probability weights. Calculations by the authors.

Figure 1 shows the increase in the use (or availability) of various forms of ICT. Several things are immediately noteworthy. First, widespread use of ICT is indeed a recent phenomenon; as late as 1995 one third of workers had (external) email in their use – a technology that by 2001 was nearly completely diffused. Overall it can be said that all workers and firms are exposed to at least some form(s) of ICT, and thus discussing diffusion in *general* may not be worthwhile. Some key technologies are, however, nowhere near their full penetration levels. For example, 'only' three fourths of manufacturing employment worked in a firm that had an intranet in 2001. The respective proportion for service employment is two thirds. Interestingly the role of *electronic data interchange* (EDI), in some sense the 'old generation' technology for inter-organizational networking, is decreasing especially in services.

We see that the use of computers has steadily increased over time in manufacturing. 58% of manufacturing and 71% of service employment used a computer (or a terminal) at work in 2001. The figure for services in considerably higher, but does not have an upward trend in recent years. The proportions of workers that are connected to local area network (LAN) or Internet have been increasing in manufacturing as well as in services.

The samples of the surveys underlying Figure 1 vary from year-to-year which, despite weighting, causes point estimates to be somewhat 'noisy'. In order to reduce the problem, we consider only firms that are included in two consecutive samples. Further, we decompose the annual changes in the ICT use among continuing firms into '*within* the firms' and '*between* the firms' effects. The within component indicates the average change in the ICT use of the firms. The between component provides us with a gauge of micro-level restructuring. It is positive when the high ICT-intensity firms increase their labor share at the cost of low ICT-intensity firms.[1] The formula the method used here is as follows:

$$\Delta INT_{ICT} = \sum \Delta INT_{ICT,i} \overline{S}_i + \sum \Delta S_i \overline{INT}_{ICT,i} \,, \tag{1}$$

where $INT_{ICT} = L_{ICT}/L$ is the ICT intensity, *i.e.*, the share of labor equipped with a computer, Internet, or LAN, $INT_{ICT,i} = L_{ICT,i}/L_i$ is the ICT intensity of the firm i, $S_i = L_i / \sum L_i$ is the employment share of the firm i in the industry, $\overline{S}_i$ and $\overline{INT}_{ICT,i}$ are the average employment share and ICT intensity of the firm i in the initial and end year, respectively.

The first term in the right-hand side of (1) is the *within* and the second the *between* component. As the decomposition method is implemented with a sample, each firm is weighted by the inverse of the sampling probability. More specifically, the average weight in the initial and end year is used. There are at least three alternative ways in analyzing the year-to-year changes. One can consider

1. the firms that are unchanged as legal entities between the two points in time (*original*),
2. the legal entities that are structurally unchanged in time, *i.e.*, have not acquired or sold plants (*filtered*), or
3. the 'synthetic' firms formed by summing up the plants the firm has continuously possessed between the two points in time (*synthetic*).

The first alternative is simple but somewhat inaccurate; the second is accurate but observations are lost quite rapidly especially if longer differences are considered; the third uses available information efficiently but obscures the definition of a firm.

Table 1 considers the changes in the proportions of ICT-equipped employment as well as decomposes the changes to within and between effects using the above discussed firm definitions. Manufacturing shows a robust growth in both computer and Internet intensities, whereas the development has been more stagnant in services, as already indi-

cated by Figure 1 above. The decompositions show that structural components (between effect) have a slight positive effect on diffusion, but overwhelmingly the growth in ICT intensity takes place within firms. In other words, no evidence was found that there is a systematic re-allocation of employment towards high ICT-intensity firms within manufacturing or services.

Table 1. Decomposition of the change in the computer and Internet intensity (based on chained sample data on 'original', 'filtered' and 'synthetic' firms as discussed above).

	Original			Filtered			Synthetic		
Manufacturing, Computers	Ch. in the sh. of *comp.* eq. labor	*Within* effect in the ch.	*Between* effect in the ch.	Ch. in the sh. of *comp.* eq. labor	*Within* effect in the ch.	*Between* effect in the ch.	Ch. in the sh. of *comp.* eq. labor	*Within* effect in the ch.	*Between* effect in the ch.
1998–1999	4.7%	4.5%	0.2%	3.2%	2.8%	0.4%	4.5%	4.3%	0.1%
1999–2000	3.3%	3.4%	0.0%	3.6%	3.8%	-0.2%	3.3%	3.4%	0.0%
2000–2001	1.5%	1.5%	0.0%	5.4%	5.4%	0.0%	2.1%	2.2%	-0.1%
1998–2001	16.1%	15.9%	0.2%	14.9%	14.0%	0.9%	17.1%	16.5%	0.5%

	Original			Filtered			Synthetic		
Manufacturing, Internet	Ch. in the sh. of *I-net* eq. labor	*Within* effect in the ch.	*Between* effect in the ch.	Ch. in the sh. of *I-net* eq. labor	*Within* effect in the ch.	*Between* effect in the ch.	Ch. in the sh. of *I-net* eq. labor	*Within* effect in the ch.	*Between* effect in the ch.
1998–1999	6.5%	6.6%	-0.1%	4.3%	4.1%	0.2%	6.5%	6.5%	0.1%
1999–2000	8.6%	9.0%	-0.3%	8.7%	9.0%	-0.2%	8.8%	9.0%	-0.2%
2000–2001	3.2%	3.3%	-0.1%	7.7%	7.7%	0.0%	4.1%	4.2%	-0.1%
1998–2001	22.1%	22.2%	-0.1%	21.1%	20.6%	0.4%	23.1%	22.7%	0.4%

	Original			Filtered			Synthetic		
Services, Computers	Ch. in the sh. of *comp.* eq. labor	*Within* effect in the ch.	*Between* effect in the ch.	Ch. in the sh. of *comp.* eq. labor	*Within* effect in the ch.	*Between* effect in the ch.	Ch. in the sh. of *comp.* eq. labor	*Within* effect in the ch.	*Between* effect in the ch.
1998–1999	1.6%	0.6%	1.0%	1.0%	0.3%	0.7%	1.5%	0.5%	1.0%
1999–2000	6.9%	7.0%	-0.1%	5.4%	4.8%	0.6%	7.0%	6.9%	0.2%
2000–2001	-2.6%	-2.3%	-0.3%	-2.3%	-2.1%	-0.2%	-2.5%	-2.3%	-0.2%
1998–2001	4.8%	5.1%	-0.3%	8.2%	6.4%	1.9%	5.3%	4.8%	0.5%

	Original			Filtered			Synthetic		
Services, Internet	Ch. in the sh. of *I-net* eq. labor	*Within* effect in the ch.	*Between* effect in the ch.	Ch. in the sh. of *I-net* eq. labor	*Within* effect in the ch.	*Between* effect in the ch.	Ch. in the sh. of *I-net* eq. labor	*Within* effect in the ch.	*Between* effect in the ch.
1998–1999	4.2%	2.6%	1.7%	2.5%	1.6%	0.9%	4.0%	2.5%	1.5%
1999–2000	6.9%	6.4%	0.5%	7.2%	6.1%	1.0%	6.8%	6.3%	0.4%
2000–2001	1.3%	1.5%	-0.2%	0.3%	0.3%	0.0%	1.5%	1.5%	0.0%
1998–2001	16.9%	14.9%	2.0%	21.1%	17.6%	3.5%	16.5%	14.4%	2.0%

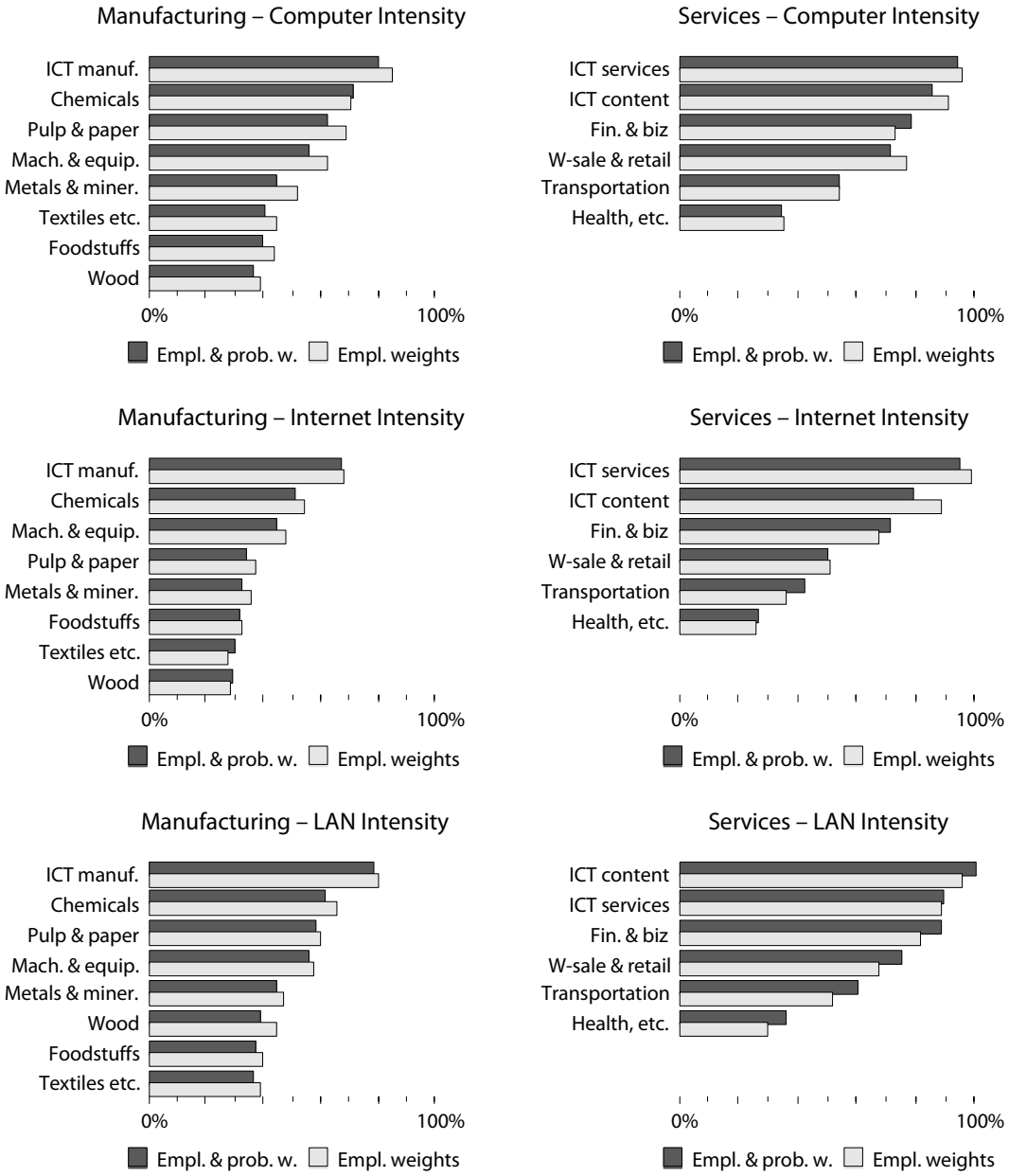
Data source: Statistics Finland's *Internet use and e-commerce in enterprises* surveys. Calculations by the authors.

It should be pointed out that above (and mostly also elsewhere in this paper) we have discussed employment-weighted results, *i.e.*, they tell about the situation a Finnish worker is facing and are thus appropriate when considering the situation at large. Results in this section are mainly driven by the situation in large and medium-sized firms. If one were to consider firm counts only, penetration rates would appear somewhat lower (these results have been reported in several Statistics Finland's publications in the *Science, Technology and Research* series).

It is quite clear that smaller firms have some disadvantages in initial implementations of many forms of ICT. For example the cost of establishing an extranet is not proportional to the intended scale of operation but rather resembles a fixed cost. Furthermore, implementing at least cutting-edge technologies has risks that larger firms may be

able to pool somewhat better. On the other hand security concerns may be higher in larger firms primarily because they are more likely targets for intrusions.

Figure 2. *Computer*, *Internet*, and *LAN* intensity by industry (estimated by weighted OLS).



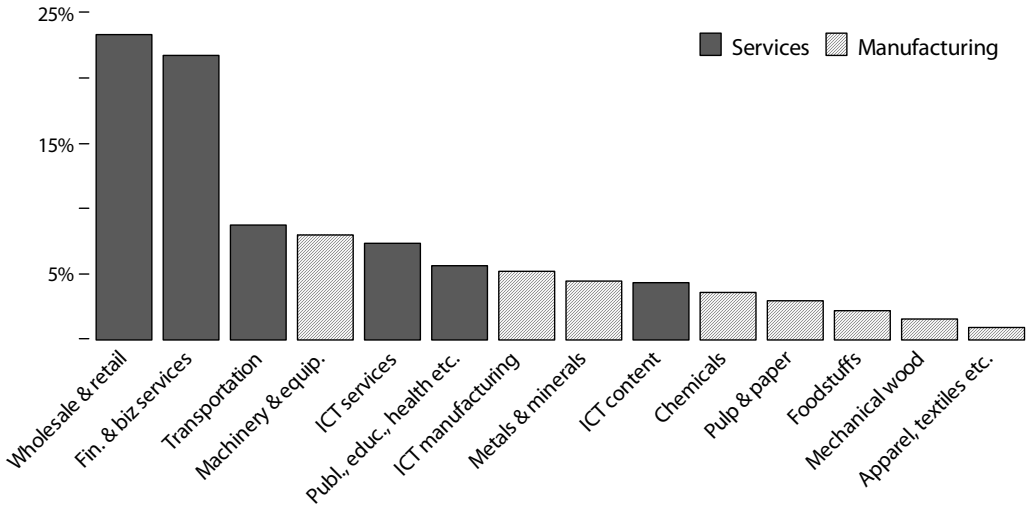
Note: Data from Statistics Finland's *Internet use and e-commerce in enterprises* surveys. Calculations by the authors. Standard errors of these estimates are 2-3 percentage points. Manufacturing industries defined as follows: Foodstuffs (15-16); Textiles etc. (17-19); Wood (20); Pulp & paper (21); Chemicals (23-25); Metals & miner. (26-28); Mach. & equip. (29, 311, 312, 314-316, 331, 334, 335, 34, 35); ICT manuf. (30, 313, 32, 332, 333). Service industries defined as follows: W-sale & retail (50-52); Transportation (60-63); Fin. & biz (65-67, 70, 71, 741-743, 745-748); Health, etc. (55, 75, 85, 90, 91, 923, 925-927, 93); ICT services (642, 72); ICT content (221, 744, 921, 922, 924). Two-digit industry explained in Table 3.

Analysis above buries the fact that there are substantial differences in ICT use between industries. These differences can be illustrated by performing a simple regression where computer, Internet, or LAN intensity is explained by a set of industry dummies. All years available for the estimation are pooled in order to have as accurate estimates as

possible for the inter-industry differences. Therefore we include dummies for different years, the reference being the last year available in the data. Estimations are performed by using employment weights and combined employment and sample weights. The results are illustrated in Figure 2. About 80 per cent of the workers use computers in the ICT-producing manufacturing industries. The corresponding number in the ICT-producing services is 95 per cent. Computer and Internet use is relatively low in foodstuffs, textiles etc., wood, and metals & minerals. Intermediate group consists of such industries as pulp & paper, chemicals, and machinery & equipment.

Based on the above intensities and the overall employment, we can obtain an estimate of the sectors' shares of the Finnish business sector (defined here as the sum of the 14 manufacturing and service sectors above) ICT capital stocks. As can be seen in Figure 3, although *wholesale & retail trade* is not among the most ICT-intensive sectors in Figure 2, its considerable size leads us to conclude that it commands over one fifth of the overall ICT capital stock. *Financial & business services* also accounts for considerable share of the overall stock. In manufacturing *machinery & equipment* commands the largest share of the stock.

Figure 3. Approximate shares of the business sector (manufacturing and services as defined above) ICT capital stock in Finland.



Note: Business sector = the sum of the 14 manufacturing and service sectors defined in Figure 2. ICT stocks calculated by taking the arithmetic mean of the employment and probability weighted Computer, Internet, and LAN intensities in Figure 2 and multiplying it by the corresponding employment.

3. PRINCIPAL COMPONENTS AND DECOMPOSITION ANALYSIS

The preliminary analysis in this section uses plant-level (as opposed to firm-level) manufacturing (as opposed to manufacturing *and* services) data.

Principal component analysis (PCA) may be seen as a method "… to reduce the dimensionality of a data set consisting of a large number of interrelated variables…" (Jolliffe, 2002, p. 1). We perform a correlation matrix -based PCA with a sample of Finnish manufacturing plants covering roughly half of manufacturing employment in year 2000. The following variables are included: measures of ICT-intensity (the computer and Internet labor shares), employee (average age of employees, average tenure in the plant, share of employees with higher technical education, and share of employees with higher non-technical education) and plant characteristics (plant age and R&D intensity).

Two principal components (PCs) with eigenvalues above one are found (results not shown but available upon request). The first PC (PC1) has an eigenvalue of nearly three and it explains over one third of the variation. It has high (positive) loadings on ICT-intensities and technical education but low (negative) loadings on plant age and employee tenure. In other words, plants with a high PC1 value tend to be relatively technology-intensive new plants.

Based on the extracted PC1 values, we divide the sample into three equally sized groups. The first group consists of plants with the highest PC1 values, which we label *new*. The last group consists of plants with the lowest PC1 values, which we label *traditional*. The remaining one third belongs to the group labeled *middle*. In what follows, productivity decompositions are applied separately for these three groups. The following productivity decomposition method is applied (Foster, Haltiwanger, & Krizan, 2001):

$$\Delta \ln P = \sum \overline{S}_i \cdot \Delta \ln P_i + \sum \left(\overline{\ln P_i} - \overline{\ln P} \right) \cdot \Delta S_i \,, \tag{2}$$

where P and P_i are the productivity indicators of the total industry and plant i, respectively and S_i is the input share of the plant i. Here input is measured by a weighted geometric average of labor input and the capital stock. The weights are determined by the respective factor income shares. We limit our analysis to the continuing plants for the reasons explained in Endnote 1.

The first term in the right-hand side of the equation is the '*within* the plants' component that indicates the (weighted) average productivity growth rate of the plants. The second term is the '*between* the plants' component. It gauges how much the plant-level restructuring has increased the aggregate productivity during the period under consideration. It is positive when there is a systematic reallocation of resources from low productivity plants to high productivity plants. So, in a sense it measures the productivity-enhancing selection among the plants.

As Figure 4 shows, there are no major differences between the three groups in the total factor productivity growth that takes place inside (within) the plants. Despite the fact that the effect of the micro-structural change is eliminated from the within component, these numbers for the 'representative plant' obviously hide a lot of heterogeneity in the *changes* in the ICT intensity between plants.

Figure 4. TFP growth *within* plants – no major differences between the groups.

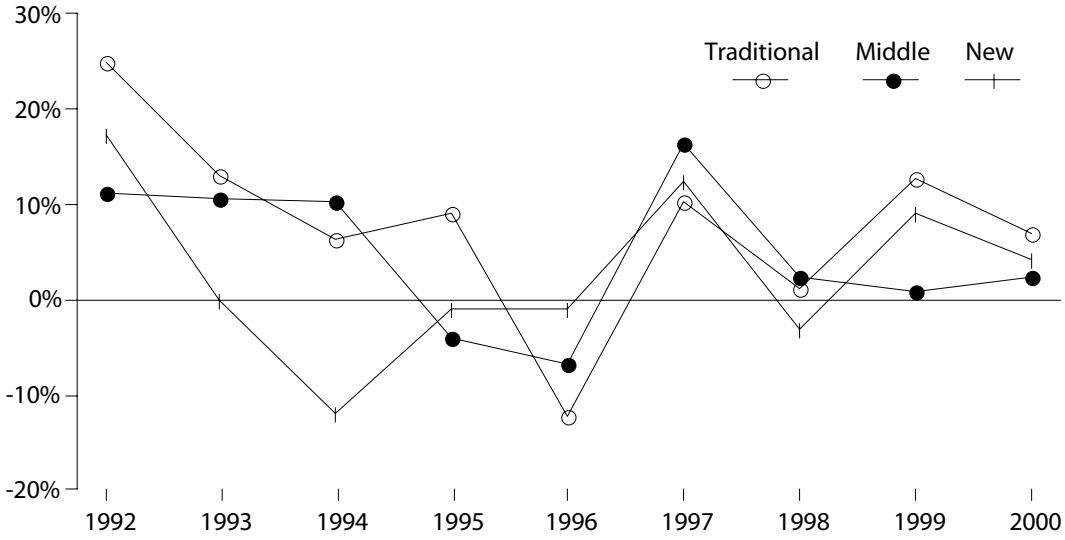


Figure 5. *Between* plants -effect in TFP growth – "creative destruction" among the new.

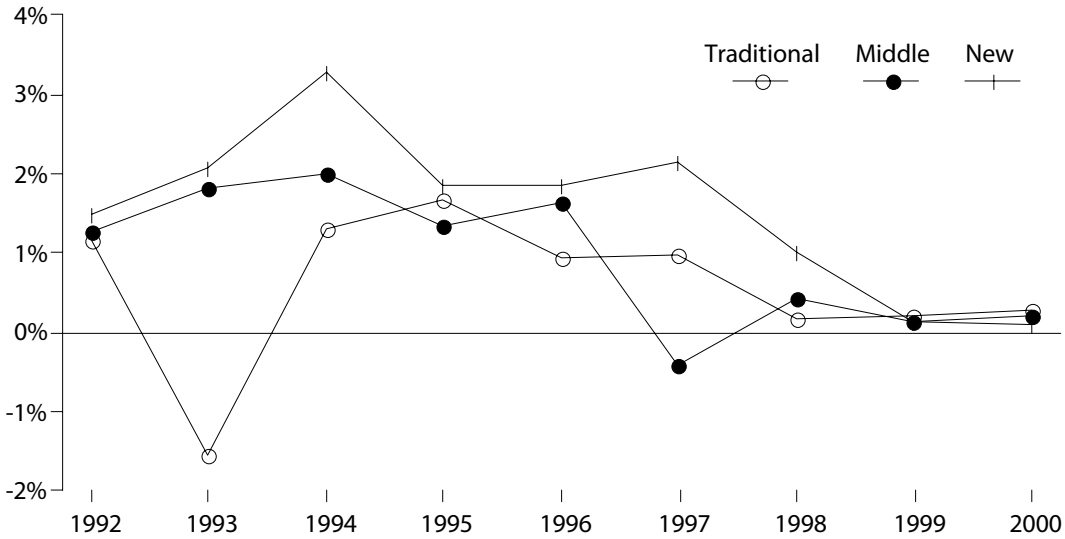
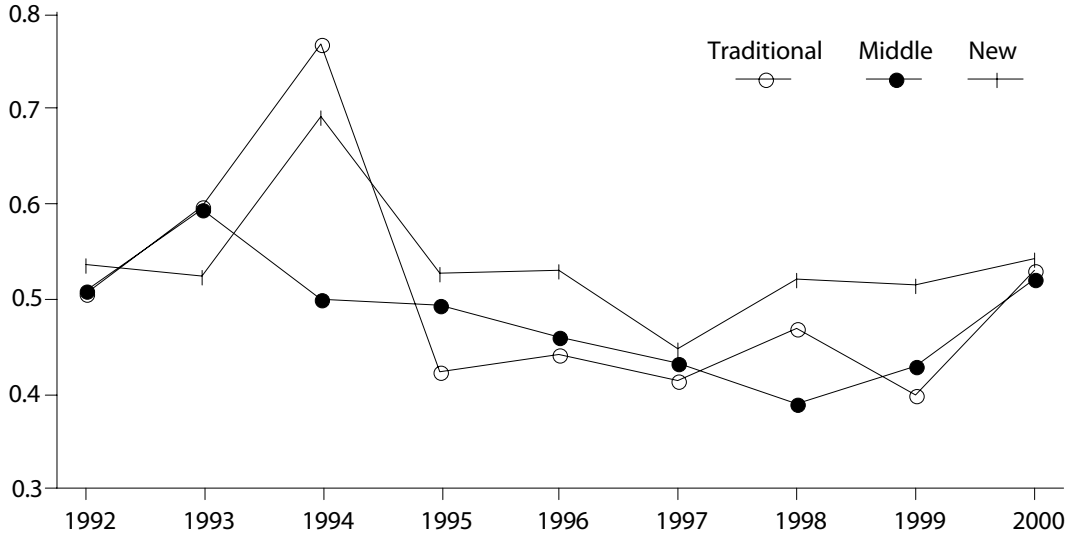


Figure 5 illustrates the development of the between component in the three groups of plants. The new have consistently higher between effect, indicating that productivity enhancing restructuring (selection) is the highest among them as compared to the other two groups. This is consistent with the argument that ICT-related experimentation by the new leads to intensive "creative destruction", *i.e.*, the ones with a successful experimentation grow and others decline. It is worth noting that since productivity decomposition is made with plant-level data these results may reflect intra-firm as well as inter-firm restructuring among the new or among the two other groups of plants. The above findings are in accordance with Maliranta (2001, pp. 37–8). His analysis indicated that a disproportionally large share of the positive between component can be attributed to high R&D intensity plants. The within component instead showed no significant differences between the high and low R&D intensity plants.

Figure 6 shows variation in TFP levels in the three groups. Two things immediately invite our attention. *First*, variation seems to have reduced in all three groups since the

mid-1990s. This is caused by the decline of low productivity plants as a consequence of the deep recession. *Second*, after the 'cutting off the lower end of the productivity distribution' had completed by mid-1990s, we observe higher variation in the TFP levels of the new. This is also consistent with experimentation, *i.e.*, possibly equally intense but nevertheless different approaches to ICT-implementations lead to different 'draws' from the productivity distribution among the new. In a competitive setting we would not expect the highly different TFP levels to persist, unless the process is not continually nourished by new innovations and further experimentation. A change in productivity dispersion suggests that the balance between the experimentation (more intense experimentation increases the dispersion) and restructuring/selection (reduces the dispersion as lower productivity plants decline) has altered in dynamically more competitive environment.

Figure 6. Standard deviation in logged TFP levels – more variation among the new.



4. Productivity effects of ICT

4.1. The decision to adopt ICT

A risk-neutral firm is expected to adopt a given form of technology as soon as the anticipated net present value of adopting is

- positive,
- higher than with any of the alternatives, and (accounting for any costs of waiting etc.)
- not expected to be higher in future points in time (as evaluated today).

Once adopted, the firm is expected to increase the intensity of its technology use until the marginal cost of employing one more unit exceeds the associated marginal revenue. While this is somewhat idealistic and oversimplified view the real-world behavior of a firm, it nevertheless provides a suitable backdrop in considering why and how firms invest in ICT.

In order to be able to acquire the technology, the firm has to be aware that it exists and that it can be applied to its line of business. To consider a given technology, the firm has to possess some related technical expertise and have sufficient absorptive capacity. After satisfying these basic pre-conditions, awareness leads to an implicit or explicit investment analysis. While this analysis is basically the same for any type of investment, the ones related to ICT do have some distinguishing characteristics.

For any given ICT investment, there is always a myriad of readily available alternatives and several new ones to be released in the near future (actual releases and vaporware – promises that are not delivered in time). Since various types of ICT should communicate with each other, one also has to consider how the investment in question relates to the current ICT stock and future additions to it. Thus, there is a high sunk cost of considering alternatives and even after considerable effort one is likely to make only a good rather than an 'optimal' choice. ICT evolves rapidly – sometimes to unexpected directions – and thus the risk of locking into an inferior technology is high. The benefits of adopting later rather than now seem high: at least hardware costs drop at double-digit rates, technological uncertainty reduces over time, and network effects accumulate as the user base expands. Many forms of ICT are in essence experience goods – they have to be used, sometimes extensively, before associated costs and benefits can be sensibly evaluated. Furthermore, the initial cost of ICT implementation may be relatively small as compared to associated investments in supporting intangible capital such as user training and organizational changes. It has been suggested that the *total* investment may be up to ten times more than the upfront ICT investment (see, e.g., Brynjolfsson, Hitt, & Yang, 2002; Brynjolfsson & Hitt, 2000). As mentioned above, ICT is indeed a general-purpose technology. Thus it is flexible enough to adapt to the *current* working practices. For example, even the most advanced networked computer happily serves as a typewriter, arguably the primary use of many office PCs. A wealth of case studies and statistical evidence shows, that the full benefits of ICT are only unleashed with supporting organizational changes.

The benefits a firm gains from ICT adoption may take a number of forms:

- The firm may get new or better related inputs possibly for less than their "full quality" price.
- ICT may improve the functioning and transparency of the markets for intermediate inputs, materials, and other factors of production.

– New possibilities for networking and outsourcing may help the firm to concentrate on its core competences and adjust the legislative boundaries of the firm accordingly.
– ICT may improve the efficiency in the functions that are kept within the firm.
– ICT may reduce marketing and logistics costs as well as expand the market(s) the firm reaches,
– ICT may make it possible to deliver higher user value in terms of price, quality, variety, convenience, timesavings, *etc.*

The benefits may translate to improvements in business performance as measured, *e.g.*, by productivity, profitability, market share, reduced inventories, capacity utilization, breadth of product range, product customization, customer value, responsiveness, innovativeness, flexibility and/or survival.

4.2. LITERATURE

Regardless of the level of aggregation, methodology, country in question, or the data set at hand, up until the mid-1990s the ICT–performance literature tended to conclude that ICT did not have measurable positive impacts (see, e.g., Brynjolfsson & Hitt, 2000; Dedrick, Gurbaxani, & Kraemer, 2003; Pilat, 2003), thus confirming the existence of Solow's infamous productivity paradox (Solow, 1987). Many later studies find that ICT is indeed positively linked to performance. At least in the leading new economies, especially in the United States but also in Finland, these benefits are considerable at the macro level (Jalava, 2002; Jalava & Pohjola, 2002; Jorgenson, 2001; Oliner & Sichel, 2000; Stiroh, 2002) and potentially huge at the micro level.

In what follows, we briefly review a few recent examples of ICT-productivity literature. ICT-performance literature at large and the ongoing work in the OECD *ICT and business performance* project is ably reviewed by Dirk Pilat (2003).

Atrostic and Nguyen (2002) use U.S. plant-level manufacturing data (year 1997 cross-section of up to 30,000 plants) to study the effects of computer networks on labor productivity. They specify a three-factor (capital, labor, materials) Cobb-Douglas (CD) production function and incorporate a computer network dummy (CNET) to the disembodied technology term.[2] Controls for skill,[3] size,[4] multiple plants (dummy), and industry (dummies) are also included. One estimated specification controls for the possible endogeneity of CNET.[5] The results show that adopting a computer network has a positive impact on labor productivity. The instrumental variables (IV) regression with the aforementioned controls suggests that productivity is five per cent higher in plants with computer networks. The ordinary least squares (OLS) coefficient estimates are over ten times smaller than the IV estimate on CNET. An OLS estimation with a two-factor CD specification yields a CNET coefficient that is twice as large as with the OLS estimation of the three-factor model.

Baldwin and Sabourin (2002) study, among other things, the effects of advanced technology (ICT) on productivity and market share using data on over 2,300 Canadian manufacturing plants. Technology variables refer to year 1998; other variables are observed for the 1988–97 period. The authors regress the 1988–97 differences of the performance measures[6] on

– the advanced technology use indicators and their interactions;
– initial size (employment), labor productivity (for the productivity equation), and market share (for the market share equation);
– foreign control dummy;

– changes in profitability (a proxy for capital intensity) and labor productivity (for the market share equation);
– R&D dummy;
– measure of plant-level aspects of innovation;
– measure of advanced business practices; as well as
– on regional dummies.

The weighted OLS regressions suggest that growth in relative labor productivity is associated with the use of network communications but not necessarily with separate use of other types of technology. Growth in market share does not appear to be associated with the use of advanced technology. Causality is not, and cannot justly be, inferred from the results.

Biscourp, Crépon, Heckel and Riedinger (2002) use a panel of over five thousand continuing French firms from 1994 to 1997 to study the effects of continuously and rapidly falling computer prices. A translog production function is specified, *i.e.*, gross output is assumed to be a function of the computer and other (non-computer) capital stocks, skilled and unskilled labor, as wells as their second-order and cross terms.[7] The authors perform between, within, and long-differenced OLS as well as first-differenced and system IV estimations (Arellano & Bond, 1991; Arellano & Bover, 1995; Blundell & Bond, 1998). The authors find that a 15% fall in the price of computing power should lead to a 0.7% decrease in marginal cost of production.

Bresnahan, Brynjolfsson and Hitt (2002) use a quasi-panel of 1,331 U.S. firms to estimate short-run input choice functions as well as a CD-type production function.[8] In the production function value added (sales-materials) is regressed on capital (IT and non-IT), labor, skills, education, work organization, and on interactions of IT with the last three. Industry and time dummies are included as controls. The authors find complementarity between IT, workplace re-organization, and new products and services. It is also found that IT capital is highly productive, which in the authors' interpretation points to large adjustment costs (work re-organization and other co-invention) associated with IT investment.

Brynjolfsson and Hitt (2002) study multi-factor productivity (MFP) growth with a 1987–94 panel of 527 large U.S. firms. The authors regress MFP growth on computer growth using a variety of specifications with and without controls for industry and time. The short-run results (using one year differences) are consistent with normal returns on computer investments. The long-run results (five to seven year differences) suggest, however, that the productivity growth contributions of computers may be up to five times higher in longer than in shorter periods. In the authors' interpretation this may suggest that computerization is associated with relatively large and time-consuming investments in complementary inputs, such as organizational capital.

Hempell (2002) uses an unbalanced 1994–99 panel of over 1,100 German service firms to study the productivity impacts of ICT. He also experiments with various estimation strategies in order to overcome estimation biases. Hempell's preferred specification (GMM-SYS, see Arellano & Bover, 1995; Blundell & Bond, 1998) regresses sales on labor, capital (ICT and non-ICT), an East-Germany dummy, as well as on interacted industry and time dummies. The results suggest that one per cent increase in ICT raises output by 0.06%, corresponding to a net return of over 50% on ICT investment.

4.3. ANALYSIS

4.3.1. BACKGROUND

As Section 2 showed, ICT penetration progressed rapidly in the late 1990s. Depending on the measure used, it grew ten to twenty percentage points in a few years. The increase was a *within* firms phenomenon – the contribution of restructuring (*between* effect) was less than one percentage point in the four year period.

TFP decompositions in Section 3 showed, that restructuring was particularly rapid among young ICT-intensive plants ('new') even though their average TFP growth were similar to other firms. This finding is consistent with intense experimentation and selection within the new group.

4.3.2. MODEL

A standard Cobb-Douglas production function of firm i at time t can be presented as

$$Y_{it} = A_{it} K_{it}^{\beta_K} L_{it}^{\beta_L} \boldsymbol{Z}_{\boldsymbol{it}}^{\boldsymbol{\beta_Z}}, \tag{3}$$

where Y is output (value added), A is *disembodied* technology, K is capital, L is labor, and $\boldsymbol{Z}$ a vector of other firm characteristics. *Embodied* technology is, by definition, included in the productive assets and/or intermediate inputs.

Assume that all workers (L) are perfect substitutes, but that they may have different marginal productivities depending on whether (L_{ICT}) or not (L_0) they use ICT. This can be introduced to (3) as follows:

$$Y_{it} = A_{it} K_{it}^{\beta_K} \left(L_{it} \left(1 + \theta_{L_{ICT}} \left(\frac{L_{ICT,it}}{L_{it}} \right) \right) \right)^{\beta_L} \boldsymbol{Z}_{\boldsymbol{it}}^{\boldsymbol{\beta_Z}}, \tag{4}$$

where $\theta_{L_{ICT}}$ is a parameter capturing the possible 'excess' productivity effect associated with the use of ICT. Slight manipulation yields the labor productivity specification

$$\ln\left(\frac{Y_{it}}{L_{it}}\right) = \ln A_{it} + \beta_K \ln\left(\frac{K_{it}}{L_{it}}\right) + \beta_L \ln\left(1 + \theta_{L_{ICT}} \left(\frac{L_{ICT,it}}{L_{it}}\right)\right) + (\beta_K + \beta_L - 1)\ln L_{it} + \boldsymbol{\beta_Z} \ln \boldsymbol{Z_{it}}, \tag{5}$$

where $(\beta_K + \beta_L - 1)\ln L_{it}$ controls for deviations from constant returns to scale (Griliches & Ringstad, 1971). Approximating $\ln\left(1 + \theta_{L_{ICT}} \left(L_{ICT,it}/L_{it}\right)\right)$ with $\left(L_{ICT,it}/L_{it}\right)$ yields

$$\ln\left(\frac{Y_{it}}{L_{it}}\right) \approx \ln A_{it} + \beta_K \ln\left(\frac{K_{it}}{L_{it}}\right) + \beta_L \theta_{L_{ICT}} \left(\frac{L_{ICT,it}}{L_{it}}\right) + (\beta_K + \beta_L - 1)\ln L_{it} + \boldsymbol{\beta_Z} \ln \boldsymbol{Z_{it}}. \tag{6}$$

An increase in A makes all factors proportionately more productive. Lehr and Lichtenberg (1999) propose that this might be the case with ICT if its primary function were to improve communication. Atrostic and Nguyen (2002), for example, incorporate a computer network dummy to A.

This leads us to consider alternative ways of introducing ICT to (3). ICT efficiency E can be defined as follows ($s_{L_{ICT}}$ indicates the share of ICT ($L_{ICT,it}/L_{it}$) and s_{L_0} the share of non-ICT ($L_{0,it}/L_{it}$) labor):

$$E_{it} = e^{s_{L0,it} + \left(1+\theta_{L_{ICT},it}\right)s_{L_{ICT},it} - 1} \tag{7}$$

If the role of ICT is merely to augment labor, (3) becomes

$$Y_{it} = A_{it} K_{it}^{\beta_K} \left(e^{s_{L0,it} + \left(1+\theta_{L_{ICT},it}\right)s_{L_{ICT},it} - 1} L_{it} \right)^{\beta_L} \boldsymbol{Z}_{\boldsymbol{it}}^{\boldsymbol{\beta_Z}} \tag{8}$$

leading to the specification considered in (6), and now the relationship is exact rather than approximate. If, instead, ICT augments output and/or increases efficiency of all inputs (and constant returns to scale prevails), (3) becomes

$$Y_{it} = A_{it} e^{s_{L0,it} + \left(1+\theta_{L_{ICT},it}\right)s_{L_{ICT},it} - 1} K_{it}^{\alpha} L_{it}^{1-\alpha} \boldsymbol{Z}_{\boldsymbol{it}}^{\boldsymbol{\beta_Z}} = A_{it} \left(e^{s_{L0,it} + \left(1+\theta_{L_{ICT},it}\right)s_{L_{ICT},it} - 1} K \right)_{it}^{\alpha} \left(e^{s_{L0,it} + \left(1+\theta_{L_{ICT},it}\right)s_{L_{ICT},it} - 1} L \right)_{it}^{1-\alpha} \boldsymbol{Z}_{\boldsymbol{it}}^{\boldsymbol{\beta_Z}} \tag{9}$$

leading to

$$\ln\left(\frac{Y_{it}}{L_{it}}\right) = \ln A_{it} + \alpha \ln\left(\frac{K_{it}}{L_{it}}\right) + \theta_{L_{ICT}} \left(\frac{L_{ICT,it}}{L_{it}}\right) + \boldsymbol{\beta_Z} \ln \boldsymbol{Z_{it}} \,. \tag{10}$$

With the exception of the ICT coefficient $\beta_L \theta_{L_{ICT}}$ that appears as $\theta_{L_{ICT}}$ above, (10) is a constant returns to scale version of (6). Estimations of (6) and (10) would be identical, but the interpretation is ICT coefficient would be somewhat different.[9]

4.3.3. Analysis

We will capture disembodied technology and industry specific shocks by defining

$$A_{it} = e^{\beta_0 + \gamma_{jt}} \tag{11}$$

where j refers to the industry of firm i. Thus, our empirical specification becomes

$$\ln\left(\frac{Y_{it}}{L_{it}}\right) = \beta_0 + \gamma_{jt} + \beta_K \ln\left(\frac{K_{it}}{L_{it}}\right) + \theta_{L_{ICT}} \left(\frac{L_{ICT,it}}{L_{it}}\right) + \left(\beta_K + \beta_L - 1\right) \ln L_{it} + \boldsymbol{\beta_Z} \ln \boldsymbol{Z_{it}} + \varepsilon_{it} \,, \tag{12}$$

where ε is the error term. Separately and together we consider three alternative measures for $L_{ICT,it}/L_{it}$ in (12):

- Share of labor using a computer or a terminal at work (*comp.*),
- Share of labor using an Internet-connected computer or a terminal at work (*I-net*), and
- Share of labor using a local area network connected computer or terminal at work (*LAN*).

Besides the ICT indicator(s), all specifications include a constant term (β_0) as well as interacted two-digit industry and annual time dummies (γ_{jt}), (log of) capital-labor ratio ($\ln(K_{it}/L_{it})$), and (log of) labor ($\ln L_{it}$). Four specifications are considered:

- *Column 1*: A basic version of (12) with $\boldsymbol{Z}$ comprising of two firm age dummies (control group: middle-aged firms)
- *Column 2*: As Column 1, but $\boldsymbol{Z}$ also includes the labor shares of lower, medium, and higher technical and non-technical education; two employment age dummies (control group: 35–44 year olds); and the labor share of female employees.
- *Column 3*: As Column 2, but the ICT indicator is now interacted with three firm age dummies.

– *Column 4*: As Column 1, but $\boldsymbol{Z}$ includes the average years of schooling which is also interacted with the ICT indicator.

We also estimated an variant of column 3 (not shown) with the ICT indicator interacted with time rather than with firm age dummies, but found no evidence for changes in the potency of ICT over time.[10]

All of the results are derived separately for manufacturing and services firms. Depending on the ICT indicator(s) used, the sample size varies from 949 to 1,444 in observations manufacturing and form 746 to 1,472 in services. Table 2 represents the basic descriptive statistics of the largest manufacturing and services samples, Table 3 shows the distribution of firms by industry, and Table 4 illustrates the time-series cross-section patterns in the data. One noteworthy point on these tables is, that the panel dimension of our data is rather weak, *e.g.*, only roughly one in ten firms is observed for the three years considered (1998–2000).

Table 2. Descriptive statistics of the largest (comp.) samples.

	Manufacturing					Services				
Variables	Obs.	Mean	St. dev.	Min.	Max.	Obs.	Mean	St. dev.	Min.	Max.
DEPENDENT: ln(value added / labor)	1,444	10.74	0.48	7.48	13.43	1,472	10.70	0.61	5.97	17.45
CD: ln(physical capital stock / labor)	1,444	10.59	1.37	5.07	17.66	1,472	9.79	1.54	4.12	20.61
ICT: sh. of comp. equipped labor	1,444	0.46	0.30	0.00	1.00	1,472	0.78	0.30	0.01	1.00
ICT: sh. of I-net equipped labor	1,412	0.28	0.28	0.00	1.00	1,446	0.61	0.39	0.00	1.00
ICT: sh. of LAN equipped labor	967	0.46	0.30	0.01	1.00	759	0.71	0.33	0.01	1.00
ICT: sh. of comp. × Firm: young	1,444	0.03	0.14	0.00	1.00	1,472	0.12	0.32	0.00	1.00
ICT: sh. of comp. × Firm: middle-aged	1,444	0.24	0.32	0.00	1.00	1,472	0.46	0.44	0.00	1.00
ICT: sh. of comp. × Firm: old	1,444	0.19	0.28	0.00	1.00	1,472	0.20	0.37	0.00	1.00
ICT: sh. of I-net × Firm: young	1,412	0.02	0.13	0.00	1.00	1,446	0.11	0.30	0.00	1.00
ICT: sh. of I-net × Firm: middle-aged	1,412	0.15	0.25	0.00	1.00	1,446	0.34	0.42	0.00	1.00
ICT: sh. of I-net × Firm: old	1,412	0.11	0.21	0.00	1.00	1,446	0.16	0.33	0.00	1.00
ICT: sh. of LAN × Firm: young	967	0.03	0.15	0.00	1.00	759	0.08	0.27	0.00	1.00
ICT: sh. of LAN × Firm: middle-aged	967	0.25	0.32	0.00	1.00	759	0.44	0.43	0.00	1.00
ICT: sh. of LAN × Firm: old	967	0.19	0.29	0.00	1.00	759	0.19	0.36	0.00	1.00
ICT: sh. of comp. × Labor: education	1,444	0.57	0.39	0.00	1.62	1,472	1.02	0.44	0.01	1.77
ICT: sh. of I-net × Labor: education	1,412	0.35	0.37	0.00	1.62	1,446	0.81	0.56	0.00	1.77
ICT: sh. of LAN × Labor: education	967	0.57	0.39	0.01	1.61	759	0.93	0.47	0.01	1.66
Firm: young (avg. plant age < 5)	1,444	0.06	0.23	0.00	1.00	1,472	0.14	0.35	0.00	1.00
Firm: old (avg. plant age > 15)	1,444	0.46	0.50	0.00	1.00	1,472	0.26	0.44	0.00	1.00
Educ.: sh. of technical, lower	1,444	0.36	0.16	0.00	0.85	1,472	0.17	0.18	0.00	1.00
Educ.: sh. of technical, med.	1,444	0.16	0.11	0.00	1.00	1,472	0.22	0.23	0.00	1.00
Educ.: sh. of technical, higher	1,444	0.04	0.08	0.00	0.69	1,472	0.08	0.14	0.00	1.00
Educ.: sh. of non-technical, lower	1,444	0.11	0.08	0.00	0.67	1,472	0.19	0.18	0.00	1.00
Educ.: sh. of non-technical, medium	1,444	0.04	0.07	0.00	1.00	1,472	0.13	0.17	0.00	1.00
Educ.: sh. of non-technical, higher	1,444	0.01	0.03	0.00	0.35	1,472	0.03	0.09	0.00	0.75
Labor: young (avg. age < 34)	1,444	0.31	0.15	0.00	1.00	1,472	0.36	0.21	0.00	1.00
Labor: old (avg. age > 45)	1,444	0.39	0.15	0.00	1.00	1,472	0.33	0.19	0.00	1.00
Labor: sh. of females	1,444	0.31	0.23	0.00	1.00	1,472	0.43	0.28	0.00	1.00
Labor: education (avg. years of)	1,444	1.19	0.09	0.99	1.62	1,472	1.28	0.14	0.90	1.77

Note: Internet and LAN variables do not correspond to the sets used in regressions. Education in tens of years.

Table 3. Number of firms by industry (largest samples).

Code	Obs.	Description
15	126	Food products, beverages
17	40	Textiles
18	34	Wearing apparel, etc.
19	20	Dressing of leather, etc.
20	93	Wood and wood products
21	79	Pulp, paper, paper prod.
22	125	Publishing, printing, etc.
23	4	Coke, nuclear fuel, etc.
24	70	Chemicals, etc.
25	73	Rubber and plastic prod.
26	73	Other non-met. mineral prod.
27	56	Basic metals
28	154	Fabricated metal products
29	185	Machinery and equipm. nec.
30	4	Electrical equipment, etc.
31	75	Electrical machinery, nec.
32	47	Radio communic. equipm. etc.
33	34	Medical instruments, etc.
34	34	Motor vehicles, etc.
35	38	Other transport equipment
36	80	Furniture, manuf. nec.
15–37	1,444	Manufacturing

Code	Obs.	Description
50	99	Sale and maintenance of motor veh.
51	304	Wholesale and commission trade
52	201	Retail trade; repair of pers. goods
55	85	Hotels and restaurants
60	24	Transport, storage and communic.
61	4	Water transport
63	6	Supporting transport activities, etc.
64	72	Post and telecommunications
70	44	Real estate, renting and business
71	10	Renting of machinery w/o operator
72	141	Computer and related activities
74	481	Other business activities
92	1	Recreational, cultural, sport act
50–93	1,472	Services

Note: If there are no usable observations for a given industry, it is excluded from the table.

Table 4. Data patterns and their frequencies in the data of the regressions below.

Largest manufacturing sample (computers)

# of firms	# of years	Firms × years	1998	1999	2000
354	1	354		1	
162	2	324		1	1
139	1	139	1		
112	3	336	1	1	1
87	2	174	1	1	
56	2	112	1		1
5	1	5			1
915	**1–3**	**1,444**			

Largest services sample (computers)

# of firms	# of years	Firms × years	1998	1999	2000
378	1	378	1		
315	1	315		1	
97	2	194		1	1
97	2	194	1		1
80	2	160	1	1	
75	3	225	1	1	1
6	1	6			1
1,048	**1–3**	**1,472**			

Smallest manufacturing sample (LAN)

# of firms	# of years	Firms × years	1998	1999	2000
391	1	391	1		
258	2	516	1	1	
63	1	63		1	
712	**1–2**	**970**			

Smallest services sample (LAN)

# of firms	# of years	Firms × years	1998	1999	2000
343	1	343	1		
157	2	314	1	1	
103	1	103		1	
603	**1–2**	**760**			

Note: LAN is the smallest of the *single* ICT indicator samples. Data patterns of the Internet and the three ICT indicator samples omitted. The former is similar to the largest and the latter to the smallest samples above.

Table 5 represents the results of estimating (12) by ordinary least squares (OLS) with *computers* as the ICT indicator. This first set of regression results is discussed in some detail; with further results we primarily concentrate on the ICT variables.

By 'fully robust' we simply mean that we employ White (1980) heteroscedasticity consistent standard errors and also allow for the dependence (autocorrelation) of observations across t. Thus, the measurement of standard errors is robust as long as i s are independently distributed (for discussion see Stata, 2001, section 23.11). The results are *weighted*, *i.e.*, they refer to the employment in manufacturing or services. We do *not* impose constant returns to scale. All of the results are also derived with and without weighting as well as with and without imposing constant returns to scale and are available upon request.

In general the alternative reported below (*weighted*, constant returns to scale *not* imposed, *interacted* time and industry dummies) seems to be the least favorable as far as finding ICT-related results is concerned,[11] but it is arguably the most appropriate one for the situation at hand.[12]

The first column of Table 5 would seem suggest that the use of a computer would increase a worker's productivity by seventeen per cent in manufacturing and by nearly thirty per cent in services. If we control for employment characteristics (the second column), the effect becomes statistically insignificant in manufacturing and reduces to ten per cent in services. What is noteworthy, however, is that the effect in manufacturing becomes again significant if the potency of ICT is studied by firm age (the third column) – the productivity effects of ICT seem to manifold in younger as compared to older firms. Similar effect is not observed in services. Contrary to our findings on ICT, other studies have shown that the productivity of (primarily non-ICT) capital tends to be higher in *older* plants possibly due to learning effects. While learning effects undoubtedly exist with ICT as well, our finding is consistent with the argument that it may be even more important to be able to make complementing organizational adjustments, arguably more easily implemented in younger firms and certainly in new firms, which by definition have a completely new organizational structure. We are unable to verify the complementarity of ICT and education (the fourth column).

As expected, physical capital intensity has a positive and significant effect on labor productivity. The estimated coefficients may seem somewhat low, but it should be kept in mind that the interacted industry and time dummies effectively remove all variation across time and industries, which has consequences on all coefficients but especially on those with significant variation by industry such as capital intensity. There seems to be increasing returns to scale in manufacturing but decreasing returns to scale in services. Older services firms tend to be considerably more productive.

In *manufacturing* high shares of employment with technical medium (bachelor level) and non-technical lower (post secondary but below bachelor level) level education seem to contribute to productivity. In our interpretation this tells that it pays to have sufficiently educated personnel at the 'factory floor'. In *services* high shares of employment with technical and non-technical higher (master level or above) as well as with technical medium level education contribute to productivity. The effect of education seems to be more straight forward in services – presumably a more educated person is able to produce a higher value added directly, *e.g.*, in professional services, whereas in manufacturing the effects are transmitted *via* process and product innovation(s) this type of labor may generate in the longer run.

Table 5. Labor productivity ($\ln(Y_{it} / L_{it})$) regressions with the share labor using a *computer* at work as the ICT indicator – pooled OLS with fully robust standard errors.

	Manufacturing				Services			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
ICT: sh. of comp. equipped labor	0.176**	0.089		-0.563	0.282***	0.106*		-1.165
	(0.081)	(0.072)		(1.387)	(0.073)	(0.063)		(0.869)
ICT: sh. of comp. × Firm: young			0.475**				0.118	
			(0.239)				(0.137)	
ICT: sh. of comp. × Firm: middle			0.166**				0.122*	
			(0.084)				(0.071)	
ICT: sh. of comp. × Firm: old			-0.066				-0.031	
			(0.141)				(0.143)	
ICT: sh. of comp. × Labor: education				0.527				1.120
				(1.179)				(0.735)
CD: ln(physical capital stock / labor)	0.120***	0.106***	0.104***	0.111***	0.123***	0.110***	0.109***	0.119***
	(0.035)	(0.031)	(0.030)	(0.036)	(0.026)	(0.026)	(0.026)	(0.026)
CD: ln(labor)	0.053***	0.067***	0.068***	0.049***	-0.029**	-0.026**	-0.026**	-0.017
	(0.017)	(0.016)	(0.016)	(0.016)	(0.012)	(0.012)	(0.013)	(0.012)
Firm: young (avg. plant age < 5)	0.041	0.107	-0.050	0.001	-0.188*	-0.121	-0.119	-0.139
	(0.063)	(0.086)	(0.120)	(0.074)	(0.101)	(0.103)	(0.134)	(0.107)
Firm: old (avg. plant age > 15)	0.019	0.057	0.176***	0.037	0.114**	0.123**	0.231*	0.131**
	(0.049)	(0.046)	(0.067)	(0.048)	(0.054)	(0.054)	(0.124)	(0.056)
Educ.: sh. of technical, lower		-0.061	-0.056			0.035	0.057	
		(0.319)	(0.317)			(0.214)	(0.221)	
Educ.: sh. of technical, med.		0.773**	0.783**			0.535**	0.557**	
		(0.340)	(0.336)			(0.211)	(0.225)	
Educ.: sh. of technical, higher		0.426	0.378			1.011***	1.021***	
		(0.642)	(0.640)			(0.279)	(0.287)	
Educ.: sh. of non-technical, lower		0.693*	0.689*			0.297	0.319	
		(0.397)	(0.398)			(0.224)	(0.228)	
Educ.: sh. of non-technical, medium		0.118	0.189			0.458	0.482	
		(0.383)	(0.384)			(0.315)	(0.323)	
Educ.: sh. of non-technical, higher		-1.090	-1.382			1.245***	1.267***	
		(0.856)	(0.876)			(0.313)	(0.321)	
Labor: young (avg. age < 34)		-0.241	-0.235			-0.298	-0.310	
		(0.253)	(0.253)			(0.239)	(0.237)	
Labor: old (avg. age > 45)		-0.320	-0.317			0.082	0.075	
		(0.230)	(0.231)			(0.232)	(0.231)	
Labor: sh. of females		-0.832***	-0.845***			-0.154	-0.143	
		(0.168)	(0.165)			(0.139)	(0.141)	
Labor: education (avg. years of)				0.699				0.204
				(0.717)				(0.686)
Also incl. a constant term as well as interacted industry and time dummies					Constant, industry × time			
Observations	1,444	1,444	1,444	1,444	1,472	1,472	1,472	1,472
Adjusted R-squared	0.48	0.54	0.55	0.49	0.46	0.50	0.50	0.49

Note: ***, ***, and * respectively indicate significance at 1, 5, and 10 % level. Standard errors in parentheses.

Computer usage may be seen as a general proxy for ICT usage in the organization in question. The next set of regressions considers Internet usage, arguably emphasizing the role of *external* electronic communication.

Table 6 represents the results of estimating (12) by ordinary least squares (OLS) with *Internet* as the ICT indicator. In *manufacturing* we find that the productivity effect of Internet is in fact *negative* especially in older plants (the second and third column). In *services*, however, the effect of Internet appears to be even larger than that of computers. The second column suggests, that, after controlling for labor characteristics, Internet-equipped labor is fifteen per cent more productive. Furthermore, with Internet we *do* observe the manifold productivity effect of ICT in younger as compared to older service firms (the third column), and the effect is qualitatively quite similar to what we found with computers in manufacturing.

Table 6. Labor productivity ($\ln(Y_{it} / L_{it})$) regressions with the share labor using an *Internet*-connected computer at work as the ICT indicator – pooled OLS with fully robust standard errors.

	Manufacturing				Services			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
ICT: sh. of I-net equipped labor	-0.073	-0.201**		0.352	0.294***	0.150**		-0.567
	(0.114)	(0.100)		(1.161)	(0.083)	(0.070)		(0.577)
ICT: sh. of I-net × Firm: young			0.311				0.402*	
			(0.210)				(0.242)	
ICT: sh. of I-net × Firm: middle			-0.174				0.158**	
			(0.125)				(0.077)	
ICT: sh. of I-net × Firm: old			-0.321**				-0.050	
			(0.136)				(0.121)	
ICT: sh. of comp. × Labor: education				-0.484				0.620
				(0.956)				(0.466)
CD: ln(physical capital stock / labor)	0.125***	0.103***	0.102***	0.105***	0.125***	0.111***	0.110***	0.118***
	(0.035)	(0.031)	(0.031)	(0.036)	(0.027)	(0.027)	(0.027)	(0.026)
CD: ln(labor)	0.052***	0.067***	0.068***	0.049***	-0.021*	-0.021*	-0.017	-0.013
	(0.016)	(0.016)	(0.016)	(0.016)	(0.013)	(0.012)	(0.013)	(0.011)
Firm: young (avg. plant age < 5)	0.047	0.105	-0.096	0.014	-0.189*	-0.130	-0.286	-0.134
	(0.068)	(0.091)	(0.103)	(0.079)	(0.097)	(0.102)	(0.217)	(0.104)
Firm: old (avg. plant age > 15)	0.015	0.055	0.092	0.038	0.120**	0.126**	0.239**	0.138***
	(0.050)	(0.046)	(0.062)	(0.047)	(0.053)	(0.053)	(0.098)	(0.053)
Educ.: sh. of technical, lower		-0.068	-0.056			0.137	0.173	
		(0.316)	(0.315)			(0.194)	(0.202)	
Educ.: sh. of technical, medium		0.867**	0.890**			0.614***	0.601***	
		(0.349)	(0.349)			(0.205)	(0.222)	
Educ.: sh. of technical, higher		0.786	0.736			1.021***	0.999***	
		(0.642)	(0.640)			(0.262)	(0.267)	
Educ.: sh. of non-technical, lower		0.650*	0.640			0.363*	0.381*	
		(0.394)	(0.398)			(0.211)	(0.213)	
Educ.: sh. of non-technical, med.		0.300	0.410			0.621**	0.632**	
		(0.366)	(0.363)			(0.275)	(0.282)	
Educ.: sh. of non-technical, higher		-0.618	-0.878			1.199***	1.212***	
		(0.805)	(0.816)			(0.303)	(0.312)	
Labor: young (avg. age < 34)		-0.282	-0.296			-0.129	-0.138	
		(0.255)	(0.253)			(0.220)	(0.220)	
Labor: old (avg. age > 45)		-0.365	-0.367			0.173	0.178	
		(0.232)	(0.231)			(0.211)	(0.211)	
Labor: sh. of females		-0.831***	-0.836***			-0.114	-0.110	
		(0.165)	(0.162)			(0.133)	(0.132)	
Labor: education (avg. years of)				1.720***				0.807**
				(0.468)				(0.410)
Also incl. a constant term as well as interacted industry and time dummies					Constant, industry × time			
Observations	1,415	1,415	1,415	1,415	1,448	1,448	1,448	1,448
Adjusted R-squared	0.48	0.55	0.55	0.50	0.46	0.50	0.51	0.50

Note: ***, ***, and * respectively indicate significance at 1, 5, and 10 % level. Standard errors in parentheses.

Whereas computers are seen a general proxy for ICT usage and Internet is seen as a proxy for external electronic communication, LAN may be seen as a proxy for the role of *internal* electronic communication in the organization in question.

Table 7 represents the results of estimating (12) by ordinary least squares (OLS) with *LAN* as the ICT indicator. Unfortunately this indicator is only available for two years, so the samples are considerably smaller. Despite this the productivity effects of ICT come through strongly and positively in both manufacturing and services. In *manufacturing* LAN-equipped labor seems to be fifteen per cent more productive. In *services* the corresponding effect is eighteen per cent. There is also some indication on the complementary of education and ICT (Services, the fourth column).

Table 7. Labor productivity ($\ln(Y_{it} / L_{it})$) regressions with the share labor using a *LAN* computer at work as the ICT indicator – pooled OLS with fully robust standard errors.

	Manufacturing				Services			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
ICT: sh. of comp. equipped labor	0.213***	0.149*		-1.259	0.310***	0.182**		-2.298*
	(0.082)	(0.078)		(1.080)	(0.081)	(0.076)		(1.220)
ICT: sh. of comp. × Firm: young			0.237				0.639	
			(0.200)				(0.702)	
ICT: sh. of comp. × Firm: middle			0.212**				0.171**	
			(0.103)				(0.072)	
ICT: sh. of comp. × Firm: old			0.029				0.140	
			(0.146)				(0.149)	
ICT: sh. of comp. × Labor: education				1.171				2.126**
				(0.928)				(1.044)
CD: ln(physical capital stock / labor)	0.118***	0.112***	0.111***	0.109***	0.129***	0.114***	0.115***	0.122***
	(0.034)	(0.031)	(0.031)	(0.035)	(0.027)	(0.027)	(0.027)	(0.026)
CD: ln(labor)	0.049**	0.060***	0.060***	0.047**	-0.042**	-0.049***	-0.048***	-0.034**
	(0.019)	(0.018)	(0.018)	(0.018)	(0.017)	(0.015)	(0.015)	(0.015)
Firm: young (avg. plant age < 5)	0.076	0.137	0.127	0.030	-0.258	-0.228	-0.627	-0.224
	(0.067)	(0.093)	(0.143)	(0.078)	(0.176)	(0.179)	(0.694)	(0.181)
Firm: old (avg. plant age > 15)	0.030	0.069	0.162**	0.046	0.054	0.043	0.063	0.071
	(0.056)	(0.053)	(0.074)	(0.055)	(0.056)	(0.060)	(0.124)	(0.055)
Educ.: sh. of technical, lower		-0.016	-0.025			0.027	0.018	
		(0.374)	(0.373)			(0.260)	(0.258)	
Educ.: sh. of technical, med.		0.979***	0.970***			0.560**	0.556**	
		(0.355)	(0.353)			(0.261)	(0.264)	
Educ.: sh. of technical, higher		-0.131	-0.144			1.107***	1.109***	
		(0.555)	(0.558)			(0.384)	(0.385)	
Educ.: sh. of non-technical, lower		0.577	0.539			0.341	0.332	
		(0.440)	(0.448)			(0.229)	(0.231)	
Educ.: sh. of non-technical, medium		0.227	0.251			0.377	0.374	
		(0.404)	(0.405)			(0.394)	(0.395)	
Educ.: sh. of non-technical, higher		-0.823	-0.926			1.619***	1.634***	
		(0.821)	(0.847)			(0.347)	(0.349)	
Labor: young (avg. age < 34)		-0.233	-0.260			-0.203	-0.210	
		(0.286)	(0.289)			(0.310)	(0.313)	
Labor: old (avg. age > 45)		-0.318	-0.351			0.230	0.223	
		(0.254)	(0.249)			(0.284)	(0.285)	
Labor: sh. of females		-0.821***	-0.832***			-0.086	-0.103	
		(0.174)	(0.170)			(0.171)	(0.160)	
Labor: education (avg. years of)				0.154				-0.456
				(0.636)				(0.982)
Also incl. a constant term as well as interacted industry and time dummies					Constant, industry × time			
Observations	970	970	970	970	760	760	760	760
Adjusted R-squared	0.46	0.52	0.52	0.47	0.49	0.54	0.54	0.53

Note: ***, ***, and * respectively indicate significance at 1, 5, and 10 % level. Standard errors in parentheses.

Table 8 runs the three ICT indicators 'against each other'. The regressions have some obvious problems not least because of collinearity between the three measures. In case of *manufacturing* the *negative* effect of Internet in older plants comes through quite clearly as does the positive effect of LAN. There is also some indication on the complementary of education and LAN. In *services* the effect of Internet is *positive* especially in younger firms (the Internet × young coefficient is significant at 15% level). There is also some indication of complementary of education and Internet.

Based on the evidence presented in this section it seems that the excess productivity effect of ICT-equipped labor typically ranges from eight to eighteen per cent. The effect tends to be larger in services than in manufacturing. The effect is often *manifold* in younger and can even be *negative* in older firms. Since organizational changes are arguably easier to implement in younger firms and recently established firms have by definition a new structure, we interpret this as evidence for the need for complementary organ-

izational changes. Manufacturing firms seem to benefit from ICT-induced efficiency in *internal* whereas service firms benefit form efficiency in *external* communication.

Table 8. Labor productivity ($\ln(Y_{it} / L_{it})$) regressions with *all* three ICT indicators – pooled OLS with fully robust standard errors.

	Manufacturing				Services			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
ICT: sh. of comp. equipped labor	0.212	0.084		0.864	0.066	-0.029		1.619
ICT: sh. of I-net equipped labor	-0.341**	-0.402***		1.795	0.259**	0.168*		-1.879
ICT: sh. of LAN equipped labor	0.203	0.233**		-4.535*	0.150	0.127		-0.165
ICT: sh. of comp. × Firm: young			0.920				-1.060	
ICT: sh. of comp. × Firm: middle-aged			0.126				0.130	
ICT: sh. of comp. × Firm: old			0.032				-0.975***	
ICT: sh. of I-net × Firm: young			0.474*				1.310	
ICT: sh. of I-net × Firm: middle-aged			-0.438**				0.104	
ICT: sh. of I-net × Firm: old			-0.419**				-0.230	
ICT: sh. of LAN × Firm: young			-1.199				0.196	
ICT: sh. of LAN × Firm: middle-aged			0.284**				0.024	
ICT: sh. of LAN × Firm: old			0.158				1.238***	
ICT: sh. of comp. × Labor: education				-0.683				-1.317
ICT: sh. of I-net × Labor: education				-1.861				1.705*
ICT: sh. of LAN × Labor: education				4.051*				0.215
Non-ICT variables as above					Non-ICT variables as above			
Also incl. a constant term as well as interacted industry and time dummies					Constant, industry × time			
Observations	949	949	949	949	746	746	746	746
Adjusted R-squared	0.47	0.54	0.54	0.50	0.49	0.54	0.55	0.53

Note: ***, ***, and * respectively indicate significance at 1, 5, and 10 % level. Standard errors omitted.

4.3.4. ICT vs. non-ICT industries

Macro-level studies have shown that overall productivity trends in Finland are largely driven by the fast productivity growth in ICT-providing industries in general and in communication equipment manufacturing in particular. In the above results industry-level effects are removed with the introduction of interacted industry and time dummies. Thus, industry-level productivity levels or trends do *not* drive the findings. It is nevertheless possible that *within* ICT industries the excess productivity of ICT-equipped labor is higher than in non-ICT industries.

Table 9 re-estimates Column (2) specifications in Table 5 for the ICT (as proxied by industries 30, 32, 64, and 72) and non-ICT industries as well as for the communications equipment industry (32) commonly associated with *Nokia*.[13] The sample sizes for the ICT and communications equipment industries are quite low, the results should be interpreted cautiously. Due to the small samples and the possible presence of one dominant company weighted and non-weighted results are considered. Since industry dummies are not applicable for the estimations for a single industry (leftmost section), to facilitate comparison also the ICT and non-ICT results are provided without industry dummies.

Comparison of the coefficients in the first row reveals that the potency of ICT seems to be manifold in ICT-provision. This finding is *not* driven by the communications equipment industry, which can be inferred from the coefficient estimates of the rightmost section. Some non-ICT coefficient estimates in the middle and rightmost sections are implausible, and thus cast doubt also on the ICT-related findings. It nevertheless seems that

ICT-providers are able to reap higher benefits from their own ICT use as compared to non-ICT firms and employment.

Table 9. Labor productivity ($\ln(Y_{it} / L_{it})$) regressions with the share labor using a *computer* at work as the ICT indicator for Non-ICT, ICT and communication equipment industries – pooled OLS with fully robust standard errors.

	Non-ICT				ICT (30, 32, 64, 72)				Communic. eq. (32)	
Weighted:	No	No	Yes	Yes	No	No	Yes	Yes	No	Yes
Dummies:	Time	Time*Ind	Time	Time*Ind	Time	Time*Ind	Time	Time*Ind	Time	Time
ICT: comp. eq.	0.197***	0.150***	0.122**	0.058	0.463**	0.370	0.439*	0.505**	-0.018	-0.200
	(0.038)	(0.044)	(0.053)	(0.053)	(0.201)	(0.258)	(0.252)	(0.245)	(0.432)	(0.427)
CD: ln(K/L)	0.132***	0.123***	0.169***	0.122***	0.103***	0.061**	0.107**	0.051	-0.037	0.054
	(0.018)	(0.020)	(0.026)	(0.023)	(0.034)	(0.025)	(0.042)	(0.037)	(0.080)	(0.132)
CD: ln(labor)	0.016	0.009	0.016	0.014	0.067**	0.071***	0.081***	0.077***	0.095*	0.186**
	(0.011)	(0.011)	(0.019)	(0.012)	(0.026)	(0.025)	(0.023)	(0.026)	(0.051)	(0.091)
Firm: young	-0.063	-0.077	-0.086	-0.133	0.145	0.112	0.263**	0.233*	0.624**	0.672**
	(0.059)	(0.060)	(0.079)	(0.083)	(0.100)	(0.102)	(0.108)	(0.121)	(0.280)	(0.299)
Firm: old	0.058**	0.055**	0.127***	0.057	0.095	0.046	0.056	-0.013	-0.350*	-0.342
	(0.023)	(0.024)	(0.042)	(0.039)	(0.077)	(0.081)	(0.125)	(0.127)	(0.204)	(0.272)
Ed.: tec., lo.	-0.154	-0.105	0.014	0.135	-0.204	-0.370	0.781	0.586	-1.774*	-2.487
	(0.094)	(0.103)	(0.226)	(0.207)	(0.396)	(0.410)	(0.688)	(0.658)	(0.926)	(1.984)
Ed.: tec., me.	0.146	0.203*	0.365	0.614***	-0.058	-0.051	0.600	0.685	-4.423**	-5.368**
	(0.103)	(0.118)	(0.257)	(0.202)	(0.334)	(0.341)	(0.554)	(0.553)	(1.739)	(1.983)
Ed.: tec., hi.	0.237	0.298	0.855**	0.465	0.556	0.561	1.997**	2.238***	5.734**	6.254*
	(0.256)	(0.264)	(0.337)	(0.318)	(0.356)	(0.353)	(0.852)	(0.772)	(2.659)	(3.086)
Ed.: n.-tec., lo.	-0.180	0.008	-0.089	0.343*	-0.575	-0.518	-1.332	-0.229	-1.185	-0.720
	(0.122)	(0.146)	(0.233)	(0.204)	(0.394)	(0.386)	(0.880)	(0.720)	(1.358)	(3.172)
Ed.: n.-tec., me.	0.184	0.217	0.363	0.371	-0.133	-0.174	2.763**	3.177***	2.330	2.644
	(0.127)	(0.136)	(0.322)	(0.241)	(0.637)	(0.633)	(1.184)	(1.046)	(4.671)	(7.801)
Ed.: n.-tec., hi.	0.892***	0.992***	0.483	0.996***	0.039	-0.084	0.061	-0.323	-4.363	-12.056
	(0.194)	(0.211)	(0.385)	(0.310)	(0.707)	(0.699)	(1.401)	(1.377)	(3.253)	(10.305)
Labor: young	-0.044	-0.047	-0.383	-0.392**	-0.120	-0.118	1.537**	0.650	0.186	-0.667
	(0.109)	(0.111)	(0.251)	(0.186)	(0.400)	(0.401)	(0.612)	(0.519)	(0.788)	(1.722)
Labor: old	0.035	0.052	-0.347	-0.230	0.378	0.237	1.471***	0.969*	0.639	0.218
	(0.128)	(0.130)	(0.266)	(0.173)	(0.421)	(0.415)	(0.550)	(0.510)	(0.779)	(1.118)
Labor: females	-0.393***	-0.322***	-0.459***	-0.419***	-0.006	-0.015	-0.576**	-0.876***	-1.672**	-2.087**
	(0.053)	(0.067)	(0.093)	(0.115)	(0.260)	(0.254)	(0.287)	(0.296)	(0.640)	(0.979)
Observations	2,652	2,652	2,652	2,652	264	264	264	264	47	47
Adj. R-squared	0.24	0.26	0.46	0.54	0.23	0.25	0.53	0.56	0.26	0.78

Note: ***, ***, and * respectively indicate significance at 1, 5, and 10 % level. Standard errors omitted.

4.3.5. The presence of a firm effect

It should be noted that the above results are consistent in large samples with relatively weak set of assumptions (see, e.g., Wooldridge, 2002, sections 7.8.1, 7.8.2 and 7.8.3 – note that a considerably weaker version of assumption POLS.3 is employed above).[14] It is nevertheless true that pooled OLS is biased and inconsistent if the firm effect is correlated with any of the explanatory variables in (12). While we can easily do away with the firm effect by a suitable transformation, this introduces a new set of problems.

The time dimension of our data is quite short and the data is best characterized as a pooled cross-sections rather than a panel, so we have a rather limited ability to deal with the possible presence of a firm effect in the usual manner. Furthermore, our legal unit -based firm identifiers may be somewhat deficient in tracing the longitudinal linkages of firms.[15] As noted above, only roughly ten per cent of the firms in the sample are observed for the three years considered. In particular, with the panels of this short it is impossible capture the effects of ICT adoption if a few years are needed to embed ICT into production system in a productive manner. Pakes and Griliches (1984) find that investments

made three to four years earlier have a greater impact on profitability than more recent investments. Lags seem to be even longer for forming intangible capital *via* R&D investments. Espost and Pierani (2003), Maliranta (2002), and Rouvinen (2002b) find evidence that returns to the most recent R&D investments are quite insignificant. These studies suggest that the returns are the highest after some four years. Given the time-consuming and cumulative characteristics of building the tangible capital and knowledge stocks within firms, it may well be the case that regression analysis in levels captures the productivity effects of ICT more reliably than changes. Evidence on the time lag between the ICT investment and its expected effects is scarce, although the findings of Brynjolfsson and Hitt (2002) would seem to suggest that the lag might be somewhere between three to seven years.

An additional practical problem is, that the 'within' variation of ICT measures during the observation period is rather small.[16] Furthermore, it is very much dominated by noise resulting from a possibly serious errors-in-variable problem. Thus, estimates originated from 'within' variation may be seriously biased towards zero.

We nevertheless estimated fixed effects and first differenced versions of the above model(s) as well as experimented with the Arellano-Bond type (Arellano & Bond, 1991; Arellano & Bover, 1995; Blundell & Bond, 1998) panel data estimators with disappointing results not only on ICT but also on other explanatory variables. Even the capital-labor ratio, the one variable having almost certainly a positive effect on labor productivity, did not come out positively and significantly in all the cases, which lends support to concerns about the reliability of these estimates.

This leads us to consider alternatives in studying the robustness of the results in the above section. One obvious alternative is to consider the firm effect as an omitted variable and employ instrumental variable (IV) techniques to reach a consistent estimate of the coefficients. The usual IV suspects are not available in our case, as industry and regional aggregates cannot be used (ind.)[17] or are unavailable (reg.) in our current data set. Indicators on the factors hampering ICT use are a potential set of instruments. Dummies indicating whether the "lack of qualified ICT personnel on the labor market hinders ICT use" and/or "market supply does not meet companies' ICT needs" seem to satisfy the necessary and sufficient conditions of IVs.[18] We instrument the ICT indicator with these two IVs and estimate a weighted and non-weighted two stage least squares (2SLS) version of Column 2 in Table 5. With weights the ICT coefficient estimate is nearly zero with a large standard error. Without weights the ICT coefficient estimate is large and positive, but only significant at about thirty per cent level.

5. Conclusions

5.1. Key findings

As shown above, widespread use of ICT is indeed a recent phenomenon. Thus analyzing its effects on productivity is without a doubt a challenge, especially if there is any kind of time lag between the introduction of a given technology and the effects it might generate. There is little research and certainly no consensus on the timing of performance gains from a given ICT investment, but according to *Cisco Systems Inc.* CEO John T. Chambers "… the greatest payoff doesn't come until seven to nine years after an [ICT] investment is made." (*Business Week*, 17 February 2003, p. 45). Not only are there possibly lengthy lags, it has been suggested that the immediate effect of a technology investment may even be negative (Huggett & Ospina, 2001). Thus, if anything, our study is likely to find the lower bound of the productivity effects of ICT use.[19]

Contrary to what was believed in the midst of the new economy boom, the increase in ICT use is largely a *within* firm phenomenon – the contribution of restructuring (*between* effect) to ICT diffusion is rather marginal (see Section 2). Even though restructuring does not seem to drive overall diffusion, this is not to say that it would not have a role to play – quite the contrary in fact. Decompositions (see Section 3) would seem to suggest that experimentation and selection is particularly intense among young ICT-intensive plants.

Evidence from the regressions (Section 4) seems to indicate that, after controlling for industry and time effects as well as labor and other firm-level characteristics, the 'lower bound estimate' of excess productivity of ICT-equipped labor ranges from eight to eighteen per cent. The effect is often *manifold* in younger firms and in ICT-providing branches and at least the immediate effect can even be *negative* in older firms. The interesting findings with regard to firm age are consistent with the need of ICT-complementing organizational changes. The finding on ICT providing branches is *not* driven by the communications equipment industry but rather by ICT services.

Overall, the ICT-induced excess productivity seems to be somewhat higher in services than in manufacturing. Manufacturing firms benefit in particular from ICT-induced efficiency in *internal* whereas service firms benefit form efficiency in *external* communication.

Our results also suggest that upon studying the effects of ICT, it is important to carefully control for human capital -related characteristics of employment – otherwise the ICT-related results can be inflated. This suggests that ICT and human capital are certainly correlated and quite likely also complementary. We indeed find weak evidence for the complementary, although the issue should be studied in more detail.

5.2. A note on policy

The work that has been done since the growth study (OECD, 2001, *The New Economy: Beyond the Hype*) draws a number of policy implications from recent ICT-performance studies. Dirk Pilat (OECD) groups these under three major headings:[20]

1. Fostering business environment for effective use of ICT,
2. Promoting competition in the provision of ICT goods and services, and
3. Boosting security and trust in relation to electronic commerce.

Under the **first** topic he notes that intense competition in the product markets promotes ICT uptake and efficient use. In our opinion this is so primarily because intense competition provides a real *downside* of not adopting, *i.e.*, firms that do not keep up with technological developments are forced to exist. Although ICT adoption may also provide an *upside*, in a competitive setting it is often short-lived, as there is a strong tendency to transfer ICT-induced benefits to customers. Besides lack of competition, excessive legislative and regulatory burden hinders adoption, as they make organizational change, skill upgrading, innovation, and management in general more difficult and/or costly.

Under the **second** topic he notes that, despite some recent problems, the evidence on the benefits of de-regulation, liberalization, and competition in the ICT provision is overwhelming. In all circumstances policies should remain technology neutral. In our opinion this is *not* the case in most OECD countries especially if one takes into account the decade-long technological and business convergence of information and communication technologies as well as (digital) content – for instance the telecom sector and in particular radio and TV remain heavily regulated and/or supported in most countries.

On the **third** topic Pilat notes that problems of security and trust remain high. Public online services are appropriately seen as a confidence builder in this respect. In our opinion there is a clear scope for policy actions in this field. Private security, authentication, and consumer protection initiatives are certainly welcomed, but in lack of supporting public decisions they are doomed. Furthermore, cross-border issues and enforcement involve cooperation of authorities in various countries and are all the more complicated in the virtual world. E-government could be the next "killer application", after online banking, boosting ICT adoption and use both at home and in business.

Also our results provide direct and/or indirect evidence on the importance of competition (restructuring), education, innovation, organizational change, and entrepreneurial dynamics (new establishments) on the adoption and efficient use of ICT.

Even accounting for the recent (over)investment boom, the fact that ICT diffusion has progressed as rapidly as illustrated above shows that the related policies have provided a reasonably good economic environment and proper incentives for ICT adoption.

The effects of ICT are by no means direct or automatic, which is precisely why we applaud the seemingly intense selection and restructuring among ICT-using firms. This "creative destruction" seems to suggest that the market has been quite successful in picking the winners from the rest. A central part of this process is the job destruction in low productivity and job creation in high productivity establishments. High pace in the implementation of the new innovations poses a challenge to the matching of workers and vacancies. Workers need incentives for regional and occupational mobility. It is also worth remarking that finding a good match between an employer and employee is difficult in the incessantly changing world and what constitutes a good match changes over time. This emphasizes the role of employment services and other active labor market measures.

One of the challenges in providing a good business environment is to maintain consistency between the aims of stimulating ICT adoption, on the one hand, and providing a fertile environment for productivity-enhancing selection and restructuring, on the other.

Besides product and labor markets, also the financial markets promote selection and restructuring. The volume by Hyytinen and Pajarinen (2003) shows that the Finnish financial system has improved greatly in recent decades, although some challenges remain for instance in the financing of growth-orientated and innovative smaller firms.

The role of education may be particularly important in fostering efficient innovation and implementation of the new technologies rather than making labor more efficient

with the current tools and technology. The great challenge of education and training is to generate an optimal *mix* of skills both in terms of levels and fields of education. A fundamental condition for successful renewal of production is that there is a sufficient supply of skills needed in innovating. However, equally important are the skills needed in implementing and using the new tools as well as willingness and ability to adopt to change. The former consist of building new (types of) plants, production systems, and organizations, and the latter of producing output with the tools already invented and implemented.

5.3. AVENUES FOR FURTHER RESEARCH

As noted in the Preface of this paper, we have merely scratched the surface of the extremely rich ICT data now available for interested researchers at *Statistics Finland*'s *research lab*. In this section we outline a few questions that one might consider addressing with it. While some of the topics will obviously be on our own research agenda, we encourage all interested researchers to elaborate on any of the ideas below. We are more than happy to provide any assistance that we can in conducting research in the topic matter.

5.3.1. POSSIBLE EXTENSIONS OF THIS STUDY

Above we have not made use of data in other surveys available at Statistics Finland. Especially the latest round of the *Community Innovation Survey* covering years 1998–2000 provides a host of interesting variables to be considered also in the context of ICT studies. With the variables in Section 10 of the survey (*muut strategiset tai organisatoriset muutokset yrityksessänne*, other strategic or organizational changes in your firm) one could easily elaborate on some of the informal arguments we have made above.

The presence of a firm effect is obviously an issue of concern. As discussed in Section 4.3.5, the standard solutions to the problem may be inadequate. Generalized instrumental variable estimator (see, e.g., Wooldridge, 2002, Section 11.4), as proposed by Hausman and Taylor (1981), may hold some promise in this context. The estimator is in essence a random effects panel-data estimator that allows for some time-varying and time-invariant dependent variables to be correlated with the individual-level random-effect. One could, for instance, have the pre-sample productivity level of firm i as an endogenous time-invariant explanatory variable and, of the time-varying variables, at least the ICT indicators could be modeled as being endogenous.

In panel data contexts it is typically assumed that the coefficients are the *same* (fixed) across individuals. Especially in the context of ICT, where we expect wildly varying outcomes of ICT investment projects as well as differences in abilities of making complementary organizational changes and co-invention, this assumption is rather heroic. It seems more reasonable to argue that we observe a sample of true coefficients drawn from a distribution. This would point to the direction of the *random coefficients approach* (or more precisely, a mixed coefficient approach, if some coefficients are modeled as fixed and some as random), not to be confused with the random effects approach.

There is also a number of more direct extensions of the above regressions. For example, with a simple re-definition of (11) one could formally introduce additional binary information on various technologies, *e.g.*, whether firm i has an EDI system or an extranet in place or not, and obtain direct excess productivity estimates for them.

The standard Cobb-Douglas framework implicitly includes a number of restrictive assumptions. It does, for instance, restrict the substitution elasticities between the factors of production to one and assumes that all factors of production are in full use (or equivalently, are instantly adjustable).[21] Since the seminal work Christensen *et al.* (1973) a voluminous literature on the flexible functional forms and on the modeling of quasi-fixed inputs in the context has emerged proposing solutions to the problem. This, and other extensions of the CD framework, should be studied.

5.3.2. Other possible extensions

It is sometimes argued that firms' investments in ICT are not necessarily motivated by productivity improvements. Instead, ICT investments help firms in their competitive process. With the help of ICT they can offer their customers value beyond that of the competition, which should translate to an increasing market share. And even if efficiency and competitiveness effects were limited, ICT investments may still be attractive if they would improve the firms' chances of survival. A related but different question is, does ICT induce new entry and/or are ICT-intensive entrants more likely to survive? At least *ad hoc* frameworks for studying these aspects could easily be specified.

As already discussed, the possible lags in the effects of ICT are largely an uncharted territory. The variables we considered are only available for a few years but as can be inferred from Figure 1, longer series on some binary ICT indicators are available (Note that distributed lag models can be estimate also with short panels. See, e.g., Pakes & Griliches, 1984). On a related note causality, in the Granger sense (1969) and in general, is an open question. Furthermore, timing of moves and possible leads or lags between the implementation of ICT and complementing organizational changes remain an open question. Rationally one would expect that the two are implemented simultaneously, but anecdotal evidence would seem to suggest organizational changes follow with a considerable lag.

As discussed in Section 4, there may be significant (and possibly unanticipated) adjustment costs after the initial ICT investment. Even though the accumulation and magnitude of these adjustment costs are an important component of an ICT invest decision, to our knowledge Bessen's (2002) paper is the only study addressing the issue directly, although economic literature offers a number of 'cook book' examples of how they could be crafted.

This paper did not discuss the issues driving (efficient) ICT adoption. Recent literature (see, e.g., Pilat, 2003) has found that factors explaining successful ICT adoption include high discounted perceived net benefit, good absorptive capability, high level of technological expertise, intensive competitive pressure, and lack of restrictive legislation. In reference to innovations is general, Boone (2000) and Aghion *et al.* (2002) argue that intense competition induces innovation and implementation new technology because of the 'escape competition' effect. Harder competition also fuels micro-level restructuring and thus the dynamic efficiency of the industry (Boone, 2000).

In a standard regression-type framework the potentially considerable effects of ICT may be hidden during the 'experimentation phase' due to the different approaches to the implementation (ICT as 'furniture' as opposed to 'innovation') and/or due to wildly different draws from the productivity distribution (co-existing good and bad outcomes depending on, e.g., technological choices and the rate of complementing organizational changes and co-invention). In such a context mean-value coefficient estimates will be biased towards zero. In a longer-term perspective we might be more interested in the pre-

vailing 'state-of-the-art' or the current 'best draw' as we would expect it to be imitated by other firms. Several alternative methods are available to study the 'efficiency envelope'.

We have no knowledge of what will ultimately be the 'best practice' in organizing ICT-assisted work. It is nevertheless obvious that for vast majority of workers, job descriptions will ultimately differ considerably from the current ones. This in turn will have consequences in the labor market and to the society at large, which should be studied.

At least *via* direct and/or indirect network effects in supply and/or demand there are spillover effects of ICT usage. By the same token there also exists a wedge between private and social returns on ICT, which in turn creates some scope for public intervention. This in turns brings about a host of interesting research questions, although the scope and magnitude of this kind of spillovers should be studied first.

The resources at *Statistics Finland* also lend themselves to a number of data-driven exercises. What are, for instance, the typical characteristics of Internet-intensive companies? The issues could be studied with, *e.g.*, the share of employees with an Internet access, a dummy indicated whether an interactive web site, or the count on the ways the Internet is being used as a dependent variable. The 1998 survey includes a section on the decentralization and outsourcing of ICT activities. With this information it would be interesting to study, what kind of ICT strategy seems to be 'optimal'? The firm's own perception on its own ICT infrastructure (whether or not it is better than that of foreign and/or domestic competitors') provides an other interesting point of departure for empirical work.

Also as a part of this project Tsupari and Rouvinen (2002) studied the interrelations of e-business and inter-firm networking. The leads of this study could be followed. As a part of its semi-annual investment survey *The Confederation of Finnish Industry and Employers* (TT) also collects information on IT investment, which so far has not been exploited in regression-type frameworks.

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Appendix: Notes on Finnish ICT data

In what follows, we discuss *official* ICT data in Finland. They are conveniently and cost-effectively available for researchers at *Statistics Finland's research laboratory*. There are numerous other sources of ICT data, but as recent work at OECD shows, they should be used cautiously. In fact in can be shown that the lack of official data in part contributed to the recent "new economy" bubble. To the best of our ability we have attempted to include all the official sources directly including ICT-related information.

Various *Statistics Finland*'s ICT, Internet, and/or e-commerce surveys are key sources of data in this paper:

- **Year 1998:** The first 'pilot' survey (*Tieto- ja viestintätekniikan käyttö yrityksissä -kysely 1999*, *Use of information and communication technology in enterprises -survey 1999*) was conducted in the beginning of 1999 and thus, in our interpretation, it primarily refers to year 1998, although retrospective and current year information was collected as well. The survey is documented in *Statistics Finland*'s publication *Tieto- ja viestintätekniikan käyttö yrityksissä* (Tilastokeskus, Tiede ja teknologia 1999:3, ISBN 951-727-684-2). Attached a copy of the questionnaire (in Finnish, a higher resolution scan available).
- **Year 1999:** The second survey (*Internet ja sähköinen kauppa yrityksissä -kysely 2000*, *Internet and e-commerce in enterprises -survey 2000*) was conducted in the beginning of year 2000 and thus, in our interpretation, it primarily refers to year 1999, although year 2000 information was collected as well. The survey is documented in *Statistics Finland*'s publication *Internet ja sähköinen kauppa yrityksissä* (Tilastokeskus, Tiede, teknologia ja tutkimus, 2000:2, ISBN 951-727-782-2). Attached a copy of the questionnaire (in Finnish, a higher resolution scan available upon request).
- **Year 2000:** The third survey (*Internet ja sähköinen kauppa yrityksissä -kysely 2001*, *Internet and e-commerce in enterprises -survey 2001*) was conducted in the beginning of year 2001 and thus, in our interpretation, it primarily refers to year 2000, although year 2001 information was collected as well. The survey is documented in *Statistics Finland*'s publication *Internet ja sähköinen kauppa yrityksissä* (Tilastokeskus, Tiede, teknologia ja tutkimus, 2001:2, ISBN 951-727-920-5). Attached a copy of the questionnaire (in Finnish).
- **Year 2001:** The fourth survey (*Internet ja sähköinen kauppa yrityksissä 2001 -kysely*, *Internet and e-commerce in enterprises 2001 -survey*)[22] was conducted in the spring of year 2002 and it primarily refers to year 2001. The survey is documented in *Statistics Finland*'s publication *Internet ja sähköinen kauppa yrityksissä 2002* (Tilastokeskus, Tiede, teknologia ja tutkimus, 2002:4, ISBN 952-467-166-2). Attached a copy of the questionnaire (in Finnish).
- **Year 2002:** The fifth survey is currently being conducted (Spring 2003).

Cross-sectional and longitudinal dimension(s) of the above survey(s) are as follows:

Cross-sectional samples (one year only)

Year 1998	Year 1999	Year 2000	Year 2001	# of obs.
X				1,300
	X			1,718
		X		2,768
			X	3,091

Three (not necessary adjacent) year panels

Year 1998	Year 1999	Year 2000	Year 2001	# of obs.
X	X	X		239
X	X		X	235
X		X	X	231
	X	X	X	366

Two (not necessary adjacent) year panels

Year 1998	Year 1999	Year 2000	Year 2001	# of obs.
X	X			439
X		X		410
X			X	406
	X	X		600
	X		X	627
		X	X	824

Four year panels

Year 1998	Year 1999	Year 2000	Year 2001	# of obs.
X	X	X	X	166

Other sources of ICT data at Statistics Finland

Besides the above-discussed surveys, the *Business Structure Statistics* (BSS) touch upon the ICT issue. BSS is an attractive statistical source, as it basically covers all establishments of firms having over 20 employees and it has been conducted since 1995. The is, however, only one 'ICT question' inquiring expenses related to purchased services. Furthermore, as recorded in BSS, these expenses are surprisingly low (typically a few per mille of the total expenses). Question 14 in section B3 is (the question and related instructions in Finnish; source: *Statistics Finland*, *Yritysten rakenteet, toimipaikan tiedot*, 2002, pp. T5/4, T5S/10):

B. TOIMIPAIKAN TUOTTOJEN JA KULUJEN ERITTELYT
B3. KULUJEN ERITTELY (ml. ostot yrityksen muilta toimipaikoilta)
14. Atk-, suunnittelu- ja ohjelmointikulut (euroa)

Erä sisältää toimipaikan ulkopuolelta hankitut, asiakkaan laskuun tapahtuvat atk-palvelut.
Ko. palveluja ovat:
- automaattiseen tietojenkäsittelyyn liittyvä laitteisto- ja ohjelmistokonsultointi
- ohjelmistojen suunnittelu ja valmistus
- tietokone- ja käsittelypalvelutoiminta, tietokantaisännöinti
- konttori- ja tietokoneiden korjaus ja huolto
- muu tietojenkäsittelypalvelu, esim. systeemityöpalvelu
- Atk-ohjelmistojen ylläpitopalvelu
- Atk-ohjelmistokonsultointi

Tähän ei kuulu:
- Atk-laitteiden vuokraus ja käyttöleasing
- Oppilaitosten ja muiden koulutusta antavien yksiköiden atk- opetus
- Atk-pohjaiset tekstinkäsittelypalvelut yrityksen laskuun
- Atk-henkilöiden vuokraus

The survey of technology and capital stocks is an additional source of official ICT-related data. In is now being conducted for the statistical year 2002. A nearly identical version of the survey has been conducted for the statistical year 1990. The survey inquires about the replacement values and economic lives of various types of capital, including ICT equipment, as well as about the use of numerically controlled machines, CAD, CAM, FMS, robots, and other ICT equipment in production. Attached the second page of the survey. Related instructions in Finnish (source: *Statistics Finland*, *Yritysten rakenteet, pääomakantakysely*, 2002, p. T51/3–4):

4.1. Toimistotietokoneet ja niiden oheislaitteet.
toimistokäyttöön tarkoitetut tietokoneet, kirjoittimet yms. myös tekstinkäsittelylaitteet
4.2. Tietokoneohjatut tuotantolaitteet, robotit, numeerisesti
ohjatut työstökoneet, automaattiset materiaalinkäsittelyjärjestelmät, tietokoneohjatut prosessilaitteistot. Mukaan luetaan myös niiden
B. Tietotekniikan käyttö
Tietoteknisten sovellusten yhteydessä on myös mainittu niiden yleisesti käytetyt englanninkieliset lyhenteet. On huomattava, että sovellukset voivat kattaa toisensa. Esim. CAM-järjestelmään kuuluvat usein osana numeeriset työstö-koneet. Merkitkää lähinnä sopivin vaihtoehto.

Tilastokeskus
Yritysten rakenteet
00022 TILASTOKESKUS

Kerätyt tiedot ovat tilastolain (62/94) mukaisesti luottamuksellisia.

Tieto- ja viestintätekniikan käyttö yrityksissä -kysely 1999

Yritystiedot

Tietotekniikalla tarkoitetaan PC-koneita (ml. Mac), kannettavia tietokoneita, päätteitä tai työasemia sekä ohjelmistoja ja käyttöjärjestelmiä, joita näissä koneissa käytetään.

Tiedustelu koskee yllämainittua yritystä, ei konsernin tietoja.

Vaihtoehtokysymyksiin kullekin riville laitetaan vain yksi rasti.

Mikäli yrityksenne ei käytä toiminnassaan lainkaan tietotekniikkaa (rasti ruutuun) ..... ☐
siirry kysymykseen 7

1. Tietotekniikan käyttö

1.1 Arvioikaa, miten suurella osalla yrityksenne kokonaishenkilöstöstä (%)

a. on käytössä tietokone tai pääte työssään ..... %
b. on käytössä sähköpostiosoite (oma tai yhteinen) ..... %
c. on pääsy Internetiin ..... %
d. on työnantajan kustantama tietokone tai mahdollisuus käyttää kannettavaa tietokonetta kotona ..... %

1.2 Käytättekö tai suunnitteletteko seuraavien tietotekniikan sovellusten käyttöä?

	otettu käyttöön vuonna	suunnitteltu 1999	ei relevantti tällä hetkellä	ei lainkaan relevantti / ei osaa sanoa
a. Sähköposti (Internet, x400 tmv.)	_____	☐	☐	☐
b. Internet (www, kotisivut)	_____	☐	☐	☐
c. EDI/OVT	_____	☐	☐	☐
d. Intranet (TCP/IP)	_____	☐	☐	☐
e. Extranet (suljettu palveluyhteys)	_____	☐	☐	☐

1.3 Onko yrityksenne tieto- ja viestintätekniikan käyttäjänä mielestänne edistyneempi kuin

	jäljessä	suunnilleen tasoissa	edellä	ei relevantti / ei osaa sanoa
a. kotimaiset kilpailijat?	☐	☐	☐	☐
b. ulkomaiset kilpailijat?	☐	☐	☐	☐

2. Internet

2.1 Mikäli yrityksenne ei käytä eikä suunnittele internet-yhteyksien käyttöönottoa tänä vuonna (rasti ruutuun) ☐ **siirry kysymykseen 2.6.**
Mihin tarkoituksiin Internetiä yrityksessänne käytetään tai on suunniteltu käytettävän ensimmäistä kertaa?

2.2 Yleiset käyttötarkoitukset	1997 tai aiemmin	1998	1999	ei relevantti tällä hetkellä	ei lainkaan relevantti / ei osaa sanoa
a. asiatiedon hankinta	☐	☐	☐	☐	☐
b. tiedostojen siirto	☐	☐	☐	☐	☐
c. oman alan kilpailijoiden seuranta	☐	☐	☐	☐	☐
d. maksuliikenne (esim. laskut, palkat)	☐	☐	☐	☐	☐
e. henkilöstön rekrytointi	☐	☐	☐	☐	☐
f. asiointi viranomaisten kanssa	☐	☐	☐	☐	☐

2.3 Yrityksenne Internet-palvelujen käyttäjänä	1997 tai aiemmin	1998	1999	ei relevantti tällä hetkellä	ei lainkaan relevantti / ei osaa sanoa
a. tavaroiden tai palvelujen hintaseuranta markkinoilla	☐	☐	☐	☐	☐
b. tavaroiden tai palvelujen tilaus sähköisesti	☐	☐	☐	☐	☐
c. tavaroiden tai palvelujen maksuliikenne	☐	☐	☐	☐	☐
d. sähköisten tuotteiden tai palvelujen vastaanotto	☐	☐	☐	☐	☐
e. kaupallisten tietokantojen tai palvelujen käyttö	☐	☐	☐	☐	☐
f. muu, mikä? _____	☐	☐	☐	☐	☐

2.4 Yrityksenne Internet-palvelujen tarjoajana	1997 tai aiemmin	1998	1999	ei relevantti tällä hetkellä	ei lainkaan relevantti / ei osaa sanoa
a. markkinointi kotisivuilla	☐	☐	☐	☐	☐
b. asiakkailla mahdollisuus selata yrityksen tietokantoja (esim. tuotteluetteloja, hinnastoja)	☐	☐	☐	☐	☐
c. tavaroiden tai palvelujen tilaus sähköisesti	☐	☐	☐	☐	☐
d. tavaroiden tai palvelujen maksuliikenne	☐	☐	☐	☐	☐
e. sähköisten tuotteiden tai palvelujen toimitukset	☐	☐	☐	☐	☐
f. myynnin jälkeiset palvelut	☐	☐	☐	☐	☐
g. muu, mikä? _____	☐	☐	☐	☐	☐

2.5 Arvioikaa sähköisen Internet-kaupan kasvu yrityksessänne seuraavan kahden vuoden aikana verrattuna nykytilanteeseen

Tilaukset, maksuliikenne ja toimitukset sähköisesti	ei lainkaan	vähäinen	suuri	ei relevantti / ei osaa sanoa
a. asiakkaiden ostot yritykseltänne	☐	☐	☐	☐
b. yrityksenne ostot muilta osapuolilta	☐	☐	☐	☐

2.6 Arvioikaa mahdollisten *esteiden merkitystä* Internetin ja sähköisen kaupan käytön tai käyttöönoton kannalta yrityksessänne
2.6.1 Internetin käyttöön liittyvät esteet yrityksenne näkökulmasta

	ei lainkaan	vähäinen	suuri	ei relevantti / ei osaa sanoa
a. tekninen osaaminen heikkoa yrityksessä	☐	☐	☐	☐
b. tietoturvaongelmat/virusvaara	☐	☐	☐	☐
c. menetetty työaika (esim. surffailu)	☐	☐	☐	☐
d. tietoliikenteen hitaus/epävarmuus yms.	☐	☐	☐	☐
e. liian suuret käyttöönotto-/ylläpitokustannukset	☐	☐	☐	☐
f. muu, mikä?	☐	☐	☐	☐

2.6.2 Sähköiseen kauppaan liittyvät esteet yrityksenne näkökulmasta

	ei lainkaan	vähäinen	suuri	ei relevantti / ei osaa sanoa
a. asiakaspotentiaali liian pieni	☐	☐	☐	☐
b. epävarmuus maksuliikenteessä	☐	☐	☐	☐
c. epävarmuus kuluttajasuojassa (takuut yms.)	☐	☐	☐	☐
d. logistiikkaan liittyvät ongelmat	☐	☐	☐	☐
e. liian suuret käyttöönotto-/ylläpitokustannukset	☐	☐	☐	☐
f. muu, mikä? _____	☐	☐	☐	☐

3. Henkilöstö

3.1 Kuinka monta tietotekniikkahenkilöä on yrityksenne palveluksessa (sekä atk-osaston henkilöstö että muissa liiketoimintayksiköissä työskentelevä yrityksen oma atk-henkilöstö)?

Arvioitu lukumäärä vuoden lopussa	**1998**	**1999**
a. kehitys ja ylläpito (ohjelmistot yms.)	_____	_____
b. käyttäjätuki, neuvonta ja koulutus	_____	_____
c. muu (johto, hallinto yms.)	_____	_____
Tietotekniikkahenkilöstö yhteensä	_____	_____
Yrityksen koko henkilöstö yhteensä	_____	_____

4. Tietotekniikkalaitteet ja yhteydet

4.1 Arvioitu lukumäärä vuoden lopussa

	1998	1999
a. PC-työasemat ja kannettavat ilman verkkoyhteyksiä	_____ kpl	_____ kpl
b. verkkoon kytketyt PC:t ja päätteet	_____ kpl	_____ kpl
YHTEENSÄ	_____ kpl	_____ kpl
c. kuinka monesta työpisteestä on yhteys ulkoiseen sähköpostiin?	_____ kpl	_____ kpl
d. kuinka monesta työpisteestä on yhteys www-sivuille?	_____ kpl	_____ kpl

4.2 Minkälainen verkkoyhteys yrityksellänne on käytössä?

a. modeemi ☐ b. ISDN ☐ c. kiinteä (mm. ATM, frame relay) ☐ d. ei verkkoyhteyttä ☐

4.3 Mikä on suurin käytössänne oleva tietoliikennenopeus yrityksenne ulkoisissa yhteyksissä?

a. ≤ 64 kbit/s ☐ b. 128 kbit/s ☐ c. 256 kbit/s ☐ d. 256 kbit/s < 2 Mbit/s ☐ e. ≥ 2 Mbit/s ☐

5. Organisaatio

5.1 Onko yrityksenne tietotekniikkatoiminnot pääosin keskitetty/hajautettu organisaatiossa vai ulkoistettu?

a. keskitetty ☐ b. hajautettu ☐ c. ulkoistettu ☐ d. ei osaa sanoa/ei relevantti ☐

5.2 Onko tietoteknikasta vastaava yksikkö yrityksessänne itsenäinen vai toimiiko se osana muita yksiköitä (esim. hallintopalvelut)?

a. itsenäinen ☐ b. osa toista yksikköä ☐ c. yksikköä ei ole ☐ d. ei osaa sanoa/ei relevantti ☐

6. Tieto- ja viestintätekniikkaan liittyvät menot

6.1 Arvioikaa yrityksenne tieto- ja viestintätekniikkaan liittyvät menot ja kokonaisliikevaihto vuonna 1998 (edellinen tilikausi)

a. ulkopuolelta ostetut tietotekniikkaan liittyvät palvelut (esim. konsultit, koulutus)	%
b. tieto- ja viestintätekniikkalaitteistot (PC:t, työasemat, kannettavat sekä näihin liittyvät oheislaitteet (printterit jne.) sekä tietoverkkoihin liittyvät laitteet (serverit, modeemit jne.)]	%
c. ohjelmistot (em. laitteisiin liittyvät ohjelmistot, lisenssimaksut)	%
d. tietotekniikkahenkilöstön menot (palkat ja muut henkilöstökulut)	%
e. muut menot (esim. tietoliikenne)	%
MENOT YHTEENSÄ	100 %

Arvio tietotekniikkamenoista yhteensä ..... _____ 000 mk
Yrityksenne kokonaisliikevaihto ..... _____ 000 mk

Kuinka suuri osuus tietotekniikkahenkilöstön menoista arvioita kohdistuu ohjelmistojen kehittämiseen omaan käyttöön? ..... %

6.2 Onko yrityksenne saanut julkista tukea (esim. EU, Tekes) tietotekniikkahankintoihin (esim. laitteet, ohjelmistot)?

ei ☐ kyllä ☐, kuinka paljon _____ 000 mk

6.3 Onko yrityksenne saanut julkista tukea (esim. EU, Tekes) henkilöstön tietotekniikkakoulutukseen?

ei ☐ kyllä ☐, kuinka paljon _____ 000 mk

7. Tietotekniikan käyttöä rajoittavat tekijät

7.1 Arvioikaa kuinka suuri merkitys seuraavilla tekijöillä on ollut yrityksenne tietotekniikan käytössä

	ei lainkaan	vähäinen	suuri	ei relevantti / ei osaa sanoa
a. tietotekniikka- ja tietoliikennemenot odotettua suuremmat	☐	☐	☐	☐
b. uusia ohjelmaversioita tulee markkinoille liian usein	☐	☐	☐	☐
c. yritysten tietotekniikkatarpeet eivät vastaa tarjontaa	☐	☐	☐	☐
d. henkilöstön tietotekniikkaosaaminen heikkoa yrityksessä	☐	☐	☐	☐
e. pula ammattitaitoisesta atk-henkilöstöstä työmarkkinoilla	☐	☐	☐	☐
f. henkilöstön motivaatio tietotekniikan käyttöön heikkoa	☐	☐	☐	☐
g. laitekanta (vanhentunut) ei sovellu uudelle teknologialle	☐	☐	☐	☐

Yhteyshenkilä

Sähköposti _____ Puhelin _____

Kommentteja .....

Kiitos vastauksestanne!

Tilastokeskus
Yritysten rakenteet
00022 TILASTOKESKUS

Kerätyt tiedot ovat tilastolain (62/94) mukaisesti luottamuksellisia.

Internet ja sähköinen kauppa yrityksissä -kysely 2000

Yritystiedot

Tietotekniikalla tarkoitetaan PC-koneita (ml. Mac), kannettavia tietokoneita, päätteitä tai työasemia sekä ohjelmistoja ja käyttöjärjestelmiä, joita näissä kysymyksissä käytetään.

Tiedustelu koskee yllämainittua yritystä, ei konsernin tietoja.

Vaihtoehtokysymyksiin kulloinkin rivillä laitetaan vain yksi rasti.

1. Tietotekniikan käyttö

1.1 Käyttääkö yrityksenne toiminnassaan tietotekniikkaa (esim. PC, tietokoneet) ☐ kyllä ☐ ei → siirry kohtaan 6

1.2 Onko yrityksenne tieto- ja viestintätekniikan käyttäjänä mielestänne edistyneempi kuin saman toimialan kilpailijat?

	jäljessä	suunnilleen tasoissa	edellä	ei osaa sanoa / ei relevantti
a. kotimaiset kilpailijat	☐	☐	☐	☐
b. ulkomaiset kilpailijat	☐	☐	☐	☐

1.3 Arvioikaa, miten suurella osalla yrityksenne kokonaishenkilöstöstä (%) on käytössä tietokone tai pääte työssään

osuus prosentteina _____%

1.4 Onko yrityksessänne käytössä lähiverkko ☐ kyllä ☐ ei → siirry kohtaan 1.6

1.5 Mikäli on, kuinka suuri osuus henkilöstöstä käyttää lähiverkkoon kytkettyä mikrotietokonetta

osuus prosentteina _____%

1.6 Käytättekö tai suunnitteletteko seuraavien tietotekniikan sovellusten käyttöä?

Ensimmäistä kertaa vuonna	1999 tai aiemmin	suunniteltu 2000	ei osaa sanoa / ei relevantti
a. Internet (www)	☐	☐	☐
b. Ulkoinen sähköpostiyhteys (esim. Internet, X400)	☐	☐	☐
c. Intranet (TCP/IP)	☐	☐	☐
d. Extranet (yrityksen ja asiakkaan välinen suljettu palveluyhteys)	☐	☐	☐

2. Internetin käyttö

2.1 Käyttääkö yrityksenne Internetiä tai onko yrityksellänne suunnitelmissa ottaa se käyttöön vuoden 2000 aikana?

☐ kyllä ☐ ei → siirry kohtaan 4

2.2 Kuinka monesta yrityksenne mikrotietokoneesta on yhteys Internet- kotisivuille?

osuus prosentteina _____%

2.3 Milloin Internet on otettu käyttöön tai sitä on suunniteltu käytettävän seuraaviin tarkoituksiin?

Yleiset käyttötarkoitukset	1999 tai aiemmin	2000	ei osaa sanoa / ei relevantti
a. asiatiedon hankinta	☐	☐	☐
b. tiedostojen siirto	☐	☐	☐
c. oman alan kilpailijoiden seuranta	☐	☐	☐
d. maksuliikenne (esim. laskut)	☐	☐	☐
e. henkilöstön rekrytointi	☐	☐	☐
f. asiointi viranomaisten kanssa	☐	☐	☐

Yrityksenne Internet-palvelujen käyttäjänä	1999 tai aiemmin	2000	ei osaa sanoa / ei relevantti
a. tavaroiden tai palvelujen hintaseuranta markkinoilla	☐	☐	☐
b. tavaroiden tai palvelujen tilaus sähköisesti	☐	☐	☐
c. tavaroiden tai palvelujen on-line maksuliikenne	☐	☐	☐
d. tuotteiden vastaanotto digitaalisessa muodossa	☐	☐	☐
e. kaupallisten tietokantojen tai -palvelujen käyttö	☐	☐	☐

2.4 Onko yrityksellänne Internet-kotisivut jo käytössä tai suunnitteilla?

☐ 1999 tai aiemmin ☐ vuonna 2000 ☐ ei käytössä eikä suunnitteilla → siirry kohtaan 4 ☐ ei osaa sanoa → siirry kohtaan 4

2.5 Milloin kotisivut on otettu käyttöön tai niitä on suunniteltu käytettävän seuraaviin tarkoituksiin?

Yrityksenne Internet-palvelujen tarjoajana	1999 tai aiemmin	2000	ei osaa sanoa / ei relevantti
a. markkinointi kotisivuilla	☐	☐	☐
b. asiakkailla mahdollisuus selata yrityksen tuotteluetteloja, hinnastoja ym.	☐	☐	☐
c. tavaroiden tai palvelujen tilaus sähköisesti	☐	☐	☐
d. tavaroiden tai palvelujen maksuliikenne	☐	☐	☐
e. tuotteiden toimitukset sähköisesti (tiedostojen suorat toimitukset tai asiakkaalla pääsy tiedostoihin)	☐	☐	☐
f. myynnin jälkeiset palvelut	☐	☐	☐

3. Sähköinen kauppa

EDI:n / OVT:n kautta vastaanotettuja EDIFACT-standardiin perustuvia tilauksia ei lasketa mukaan (ks. kohta 5).

3.1 Arvioikaa sähköisen Internet-kaupan asiakasryhmien merkitystä yrityksenne näkökulmasta?

	ei lainkaan	vähäinen	suuri	ei osaa sanoa / ei relevantti
a. muut yritykset	☐	☐	☐	☐
b. kotitaloudet	☐	☐	☐	☐
c. julkinen sektori	☐	☐	☐	☐

3.2 Miten suuri merkitys seuraavilla tekijöillä on yrityksenne kannalta liittyen sähköiseen kaupankäyntiin?

	ei lainkaan	vähäinen	suuri	ei osaa sanoa / ei relevantti
a. kustannusten vähentäminen	☐	☐	☐	☐
b. yrityskuva	☐	☐	☐	☐
c. uusien alihankkijoiden löytäminen	☐	☐	☐	☐
d. uusien asiakkaiden löytäminen	☐	☐	☐	☐
e. pääsy laajemmille markkinoille	☐	☐	☐	☐
f. asiakaspalvelun ja joustavuuden paraneminen	☐	☐	☐	☐
g. uusien tuotteiden lanseeraaminen markkinoille	☐	☐	☐	☐
h. paikka markkinaosuuksien menetyksestä muille verkossa oleville yrityksille	☐	☐	☐	☐

3.3 Arvioikaa kuinka suuri osuus (%) yrityksenne liikevaihdosta kertyy Internetin kautta saaduista tilauksista?

	ei lainkaan	≤1%	2-4%	5-9%	10-24%	25-49%	50% tai enemmän	ei osaa sanoa / ei relevantti
vuonna 1999	☐	☐	☐	☐	☐	☐	☐	☐
vuonna 2000 (arvio)	☐	☐	☐	☐	☐	☐	☐	☐

4. Internetin käyttöön liittyvät esteet

Arvioikaa mahdollisten esteiden merkitystä Internetin ja sähköisen kaupan käytön tai käyttöönoton kannalta yrityksessänne

4.1 Internet

	ei lainkaan	vähäinen	suuri	ei osaa sanoa / ei relevantti
a. tietoturvaongelmat/virusvaara	☐	☐	☐	☐
b. tekninen osaaminen heikkoa yrityksessä	☐	☐	☐	☐
c. liian suuret käyttöönotto-/ylläpitokustannukset	☐	☐	☐	☐
d. menetetty työaika (esim. surffailu)	☐	☐	☐	☐
e. tietoliikenteen hitaus/epävarmuus yms.	☐	☐	☐	☐

4.2 Sähköinen kauppa

	ei lainkaan	vähäinen	suuri	ei osaa sanoa / ei relevantti
a. yrityksen tuotteet eivät sovellu myyntiin Internetissä	☐	☐	☐	☐
b. asiakaspotentiaali liian pieni	☐	☐	☐	☐
c. epävarmuus maksuliikenteessä	☐	☐	☐	☐
d. epävarmuus kuluttajasuojassa (takuut yms.)	☐	☐	☐	☐
e. logistiikkaan liittyvat ongelmat	☐	☐	☐	☐
f. liian suuret käyttöönotto-/ylläpitokustannukset	☐	☐	☐	☐

5. EDI / OVT

EDI/OVT (Electronic Data Interchange / Organisaatioiden välinen tiedonsiirto) on menettely, jossa asiakirja korvataan yrityksen tietojärjestelmässä sijaitsevista tiedoista tuotetulla määrämuotoisella sanomalla, joka välitetään sähköisesti vastaanottavaan yritykseen ja puretaan siellä automaattisesti suoraan tietojärjestelmään, esim. tilaus, laskun maksuosoitus pankkiin, hinnasto tai tuoteluettelo.

5.1 Käyttääkö yrityksenne EDIä (OVT) tai onko yrityksellänne suunnitelmissa ottaa se käyttöön vuoden 2000 aikana?

☐ kyllä ☐ ei → siirry kohtaan 6

5.2 Milloin EDI on otettu tai aiotaan ottaa käyttöön yrityksessänne?

☐ 1999 tai aiemmin ☐ vuonna 2000 ☐ ei osaa sanoa / ei relevantti

5.3 Milloin EDI on otettu tai aiotaan ottaa käyttöön seuraavien tahojen kanssa?

	1999 tai aiemmin	2000	ei osaa sanoa / ei relevantti
a. asiakkaat	☐	☐	☐
b. alihankkijat	☐	☐	☐
c. muut yhteistyökumppanit	☐	☐	☐
d. rahoitus- ja vakuutuslaitokset	☐	☐	☐
e. viranomaiset ja muut organisaatiot	☐	☐	☐

6. Tietotekniikan käyttöä rajoittavat tekijät

Arvioikaa kuinka suuri merkitys seuraavilla tekijöillä on ollut yrityksenne tietotekniikan käytössä

	ei lainkaan	vähäinen	suuri	ei osaa sanoa / ei relevantti
a. tietotekniikka- ja tietoliikennemenot odotettua suuremmat	☐	☐	☐	☐
b. uusia ohjelmaversioita tulee markkinoille liian usein	☐	☐	☐	☐
c. tarjonta ei vastaa yritysten tietotekniikkatarpeita	☐	☐	☐	☐
d. henkilöstön tietotekniikkaosaaminen heikkoa yrityksessä	☐	☐	☐	☐
e. pula ammattitaitoisesta atk-henkilöstöstä työmarkkinoilla	☐	☐	☐	☐
f. henkilöstön motivaatio tietotekniikan käyttöön heikkoa	☐	☐	☐	☐

Mikä oli yrityksenne liikevaihto vuoden 1999 aikana (arvio) _____ **miljoonaa markkaa**

Yhteyshenkilö .....

Sähköposti ..... Puhelin .....

Kommentteja .....

Kiitos vastauksestanne!

Tilastokeskus

Yritysten rakenteet
00022 TILASTOKESKUS

Kerätyt tiedot ovat tilastolain (62/94) mukaisesti luottamuksellisia.

Internet ja sähköinen kauppa yrityksissä -kysely 2001

Yritystiedot

Tiedustelu koskee yllämainittua yritystä, ei konsernin tietoja.

Vaihtoehtokysymyksiin kullekin riville laitetaan vain yksi rasti, ellei muuta mainita.

1. Tietotekniikan käyttö

1.1 Käyttääkö yrityksenne toiminnassaan tietokoneita?

☐ kyllä ☐ ei → siirry kohtaan 5

1.2 Kuinka suuri osa yrityksenne henkilöstöstä käyttää tietokonetta tai päätettä työssään?

osuus prosentteina _____%

1.3 Onko yrityksessänne käytössä lähiverkko?

☐ kyllä ☐ ei → siirry kohtaan 1.5

1.4 Kuinka suuri osuus yrityksenne henkilöstöstä käyttää lähiverkkoon kytkettyä mikrotietokonetta?

osuus prosentteina _____%

1.5 Millä teknisellä ratkaisulla yrityksenne tietokoneiden verkkoyhteydet on hoidettu toimipisteenne ulkopuolisiin tietokoneisiin? (Useampi vaihtoehto mahdollinen.)

☐ yrityksellä ei verkkoyhteyksiä ☐ modeemi (analoginen) ☐ ISDN

☐ xDSL (Esim ADSL, SDSL jne.) ☐ matkapuhelin ☐ muu laajakaistainen yhteys (>2Mbps)

2. Internetin käyttö

2.1 Onko yrityksellänne jo käytössä tai suunnitelmissa vuoden 2001 aikana ottaa käyttöön seuraavia tietotekniikan sovelluksia?

	käytössä 2000 tai aiemmin	suunniteltu 2001	ei käytössä eikä suunniteltu 2001	ei osaa sanoa/ ei relevanttia
a. Internet (www)	☐	☐	☐	☐
b. Ulkoinen sähköpostiyhteys	☐	☐	☐	☐
c. Intranet (käytössä vain yrityksen sisäisesti)	☐	☐	☐	☐
d. Extranet (yrityksen ja asiakkaan välinen suljettu palveluyhteys)	☐	☐	☐	☐

→ *Jos yrityksellänne ei ole käytössä Internetiä eikä suunnitelmissa ottaa sitä käyttöön vuoden 2001 aikana siirtykää kysymykseen 3.2*

2.2 Kuinka suuri osa yrityksenne työntekijöistä käyttää mikrotietokonetta, josta on yhteys Internetiin?

osuus prosentteina _____%

2.3 Milloin Internet on otettu tai on suunniteltu otettavan käyttöön seuraaviin tarkoituksiin?

Yrityksenne Internet-palvelujen käyttäjänä	2000 tai aiemmin	suunniteltu 2001	ei käytössä eikä suunniteltu 2001	ei osaa sanoa/ ei relevantti
a. asiatiedon hankinta	☐	☐	☐	☐
b. oman alan kilpailijoiden seuranta	☐	☐	☐	☐
c. tiedonhankinta yhteistyökumppaneiden kotisivuilta	☐	☐	☐	☐
d. pankkiasioiden hoito (esim. laskut, palkat)	☐	☐	☐	☐
e. henkilöstön rekrytointi	☐	☐	☐	☐
f. asiointi viranomaisten kanssa	☐	☐	☐	☐
g. tavaroiden tai palvelujen vastaanotto verkosta digitaalisessa muodossa (esim. tietokoneohjelmat)	☐	☐	☐	☐

2.4 Onko yrityksellänne Internet-kotisivut jo käytössä tai suunnitteilla ja milloin ne on otettu käyttöön tai ne on suunniteltu otettavan käyttöön seuraaviin tarkoituksiin?

Yrityksenne Internet-palvelujen tarjoajana	2000 tai aiemmin	suunniteltu 2001	ei käytössä eikä suunniteltu 2001	ei osaa sanoa/ ei relevantti
a. Internet-kotisivut	☐	☐	☐→ siirry kohtaan 3.1.8	☐→ siirry kohtaan 3.1.8
b. markkinointi kotisivuilla	☐	☐	☐	☐
c. asiakkailla mahdollisuus selata yrityksen tuoteluetteloja, hinnastoja ym.	☐	☐	☐	☐
d. tavaroiden tai palvelujen tilaus sähköisesti	☐	☐	☐	☐
e. tuotteiden toimitukset sähköisesti (tiedostojen/datan suorat toimitukset tai asiakkaalla pääsy tiedostoihin)	☐	☐	☐	☐
f. myynnin jälkeiset palvelut	☐	☐	☐	☐

3. Sähköinen kauppa

Sähköisellä kaupalla tarkoitetaan tietokoneverkon kautta suoritettuja tavaroiden ja palvelujen tilauksia. Maksu- tai toimitustavalla ei ole merkitystä. Sähköistä kauppaa käydään esim. Internetin (kohta 3.1) tai EDIn (kohta 3.2) kautta.

3.1 Internet-kauppa

XML/EDIn eli Internetin kautta käytettävän EDIn kautta tehdyt tilaukset lasketaan Internet-kauppaan. EDIFACT-standardiin perustuvan EDIn/OVT:n kautta tehtyjä tilauksia ei lasketa Internet-kauppaan. Niistä kohdassa 3.2.

A Internet-kauppa yrityksenne kotisivujen kautta tapahtuvassa myynnissä

3.1.1 Onko yrityksenne kotisivuilla käytössä palvelu, jonka kautta asiakkaat voivat tilata yrityksenne tuotteita tai palveluita tai onko tällainen palvelu suunnitteilla vuonna 2001?

☐ käytössä 2000 tai aiemmin ☐ suunnitteilla vuonna 2001 ☐ ei käytössä eikä suunnitteilla vuonna 2001 → siirry kohtaan 3.1.8 ☐ ei osaa sanoa → siirry kohtaan 3.1.8

3.1.2 Onko yrityksenne kotisivuilla käytössä palvelu, jossa yritykseltänne tilatut tuotteet ja palvelut voi maksaa suoraan kotisivujenne kautta tai onko tällainen palvelu suunnitteilla vuonna 2001?

☐ käytössä 2000 tai aiemmin ☐ suunnitteilla vuonna 2001 ☐ ei käytössä eikä suunnitteilla vuonna 2001 ☐ ei osaa sanoa

3.1.3 Myykö yrityksenne tuotteita tai palveluja toisille yrityksille erikoistuneiden B2B Internet -markkinapaikkojen kautta?

B2B Internet -markkinapaikalla tarkoitetaan Internetissä toimivaa palvelusivustoa, jossa kerätään yhteen paikkaan tietoja yritysten toisille yrityksille tarjoamista palveluista ja tuotteista ja jonka kautta toiset yritykset voivat näiden tietojen pohjalta tehdä tilauksia tarjoavilta yrityksiltä.

☐ kyllä ☐ ei

3.1.4 Arvioikaa yrityksenne eri asiakasryhmiltä Internetin kautta saamien tilausten osuutta yrityksenne Internetin kautta saamien tilausten kokonaisarvosta vuonna 2000.

a. yksityiset yritykset _____% + b. kotitaloudet _____% + c. julkinen sektori _____% = **100%**

3.1.5 Arvioikaa yrityksenne eri maista Internetin kautta saamien tilausten osuutta yrityksenne Internetin kautta saamien tilausten kokonaisarvosta vuonna 2000.

a. Suomi _____% + b. muu EU _____% + c. muut maat _____% = **100%**

3.1.6 Arvioikaa kuinka suuri osuus yrityksenne liikevaihdosta kertyy Internetin kautta saaduista tilauksista.

osuus prosentteina vuonna 2000 _____% osuus prosentteina vuonna 2001 _____%

3.1.7 Miten suuri merkitys seuraavilla tekijöillä on yrityksenne Internet-kauppaan?

	ei lainkaan	vähäinen	suuri	ei osaa sanoa/ ei relevantti
a. kustannusten vähentäminen	☐	☐	☐	☐
b. prosessien nopeutuminen	☐	☐	☐	☐
c. yrityskuva	☐	☐	☐	☐
d. uusien alihankkijoiden löytäminen	☐	☐	☐	☐
e. uusien asiakkaiden löytäminen	☐	☐	☐	☐
f. pääsy laajemmille markkinoille	☐	☐	☐	☐
g. asiakaspalvelun ja joustavuuden paraneminen	☐	☐	☐	☐
h. uusien tuotteiden lanseeraminen markkinoille	☐	☐	☐	☐
i. pelko markkinaosuuksien menetyksestä	☐	☐	☐	☐

B Internet-kauppa yrityksenne hankinnoissa

3.1.8 Milloin Internet on otettu tai on suunniteltu otettavan käyttöön seuraaviin tarkoituksiin?

	2000 tai aiemmin	suunniteltu 2001	ei käytössä eikä suunniteltu 2001	ei osaa sanoa/ ei relevantti
a. tavaroiden ja palveluiden hankinta	☐	☐	☐	☐
b. kaupallisten tietokantojen käyttö	☐	☐	☐	☐
c. hankintojen maksaminen suoraan tavaran tai palvelujen myyjän kotisivuilla (on-line)	☐	☐	☐	☐

3.1.9 Hankkiiko yrityksenne tuotteita tai palveluja toisilta yrityksiltä erikoistuneiden B2B Internet -markkinapaikkojen kautta?

B2B Internet -markkinapaikalla tarkoitetaan Internetissä toimivaa palvelusivustoa, jossa kerätään yhteen paikkaan tietoja yritysten toisille yrityksille tarjoamista palveluista ja tuotteista ja jonka kautta toiset yritykset voivat näiden tietojen pohjalta tehdä tilauksia tarjoavilta yrityksiltä.

☐ kyllä ☐ ei

3.1.10 Arvioikaa kuinka suuri osuus yrityksenne kaikkien hankintojen arvosta kertyi Internetin välityksellä tekemistänne tilauksista vuonna 2000.

osuus prosentteina vuonna 2000 _____%

3.2 EDI / OVT

EDI/OVT (Electronic Data Interchange / Organisaatioiden välinen tiedonsiirto) on menettely, jossa asiakirja korvataan yrityksen tieto järjestelmässä sijaitsevista tiedoista tuotetulla määrämuotoisella sanomalla, joka välitetään sähköisesti vastaanottavaan yritykseen ja puretaan siellä automaattisesti suoraan tietojärjestelmään (esim. tilaus, laskun maksuosoitus pankkiin, hinnasto tai tuoteluettelo).

Tässä otetaan huomioon vain EDIFACT-standardiin perustuva EDI. Esimerkiksi XML/EDIä, jota käytetään Internetin yhteydessä ei lasketa tähän (kts. kohta 3.1).

3.2.1 Käyttääkö yrityksenne EDIä tai onko yrityksellänne suunnitelmissa ottaa se käyttöön vuoden 2001 aikana?

☐ otettu käyttöön 2000 tai aiemmin ☐ suunnitelmissa vuonna 2001 ☐ ei → siirry kohtaan 4

3.2.2 Minkä tahojen kanssa EDI on otettu käyttöön tai aiotaan ottaa käyttöön vuonna 2001?

☐ pankit ja rahoituslaitokset ☐ muut yritykset ☐ viranomaiset ja järjestöt

3.2.3 Arvioikaa kuinka suuri osuus yrityksenne liikevaihdosta kertyy EDIn välityksellä saaduista tilauksista.

osuus prosentteina vuonna 2000 _____% osuus prosentteina vuonna 2001 _____%

3.2.4 Arvioikaa kuinka suuri osuus yrityksenne kaikkien hankintojen arvosta kertyi EDIn välityksellä tekemistänne tilauksista vuonna 2000.

osuus prosentteina vuonna 2000 _____%

4. Internetin käyttöön liittyvät esteet

Arvioikaa mahdollisten esteiden merkitystä Internetin ja Internet-kaupan käytön tai käyttöönoton kannalta yrityksessänne

4.1 Internet

	ei lainkaan	vähäinen	suuri	ei osaa sanoa/ ei relevantti
a. tietoturvaongelmat / virusvaara	☐	☐	☐	☐
b. tekninen osaaminen riittämätöntä yrityksessä	☐	☐	☐	☐
c. teknisesti liian monimutkaista	☐	☐	☐	☐
d. tietokoneet ja ohjelmat liian kalliita	☐	☐	☐	☐
e. kotisivujen kehittämisen ja ylläpidon kustannukset	☐	☐	☐	☐
f. liian suuret tietoliikennekulut	☐	☐	☐	☐
g. menetetty työaika (esim. surffailu)	☐	☐	☐	☐
h. tietoliikenteen hitaus / epävarmuus yms	☐	☐	☐	☐
i. Internetin käytöstä on liian vähän hyötyä odotettavissa yritykselle	☐	☐	☐	☐

4.2 Internet-kauppa yrityksenne myynnissä

	ei lainkaan	vähäinen	suuri	ei osaa sanoa/ ei relevantti
a. yrityksen tuotteet eivät sovellu myyntiin Internetissä	☐	☐	☐	☐
b. asiakaspotentiaali liian pieni	☐	☐	☐	☐
c. epävarmuus maksuliikenteessä	☐	☐	☐	☐
d. epävarmuus kuluttajasuojassa (takuut yms.)	☐	☐	☐	☐
e. painopiste nykyisissä jakelukanavissa	☐	☐	☐	☐
f. logistiikkaan liittyvät ongelmat	☐	☐	☐	☐
g. liian suuret käyttöönotto-/ylläpitokustannukset	☐	☐	☐	☐

5. Tietotekniikan käyttöä rajoittavat tekijät

Arvioikaa kuinka suuri merkitys seuraavilla tekijöillä on yrityksenne tietotekniikan käyttöä rajoittavana tekijänä.

	ei lainkaan	vähäinen	suuri	ei osaa sanoa/ ei relevantti
a. tietotekniikkamenot liian suuret/odotettua suuremmat	☐	☐	☐	☐
b. uusia ohjelmaversioita tulee markkinoille liian usein	☐	☐	☐	☐
c. tarjonta ei vastaa yrityksen tietotekniikkatarpeita	☐	☐	☐	☐
d. henkilöstön tietotekniikkaosaaminen riittämätöntä	☐	☐	☐	☐
e. ammattitaitoisen atk-henkilöstön rekrytointiongelmat	☐	☐	☐	☐
f. henkilöstö vastahakoista käyttämään tietotekniikkaa	☐	☐	☐	☐

Mikä oli yrityksenne liikevaihto vuoden 2000 aikana (arvio) _____ miljoonaa markkaa

Yhteyshenkilö .....

Sähköposti ..... Puhelin .....

Kommentteja .....

.....

.....

.....

.....

Kiitos vastauksestanne!

Tilastokeskus

Yritysten rakenteet
Tiede, teknologia ja tietoyhteiskunta
00022 TILASTOKESKUS

Tällä lomakkeella kerätyt tiedot ovat tilastolain (62/94) mukaan salassapidettäviä

Internet ja sähköinen kauppa yrityksissä 2001- kysely

Tässä tutkimuksessa kerätään tietoja yritysten tietoteknikan käytöstä, erityisesti Internetin käytöstä ja sähköisestä kaupasta.
Kysely koskee myös yrityksiä, joilla ei ollut käytössä Internetiä tai sähköistä kauppaa vuonna 2001.

Tiedot koskevat oheista yritystä
(korjatkaa tarvittaessa).

1. Tietotekniikan käyttö

1.1 Käyttääkö yrityksenne toiminnassaan tietokoneita?	kyllä ☐	ei ☐ →	siirry osioon 6
1.2 Kannettavien tietokoneiden osuus yrityksenne tietokoneista (ei kämmenmikroja)	osuus prosentteina ____%		
1.3 Kuinka suuri osa yrityksenne henkilöstöstä käyttää tietokonetta työssään?	osuus prosentteina ____%		

2. Internetin käyttö

2.1 Oliko yrityksellänne Internet-yhteys vuonna 2001 tai suunnitelmissa hankkia sellainen vuonna 2002?

a. käyttössä 2001 ☐
b. suunniteltu 2002 ☐
c. ei käyttössä eikä suunniteltu 2002 ☐ → siirry osioon 4
d. en osaa sanoa ☐ → siirry osioon 4

2.2 Millä teknisellä ratkaisulla yrityksenne Internet-yhteydet on järjestetty?

(Useampi vaihtoehto mahdollinen)

a. modeemi (analoginen) ☐
b. ISDN ☐
c. xDSL (Esim. ADSL, SDSL jne.) ☐
d. kiinteä langaton yhteys ☐
e. muu kiinteä yhteys (< 2 Mbps) ☐
f. muu kiinteä yhteys (≥ 2 Mbps) ☐
g. muu langaton yhteys (esim. matkapuhelin) ☐
h. en osaa sanoa ☐

2.3 Oliko yrityksellänne käytössä vuonna 2001

	kyllä	ei
a. Sähköposti	☐	☐
b. Intranet [1]	☐	☐
c. Ekstranet [2]	☐	☐

2.4 Onko yrityksessänne käytetty Internetiä työtehtävissä seuraaviin tarkoituksiin vuonna 2001?

Yrityksenne Internet-palvelujen käyttäjänä.

	kyllä	ei
a. asiatiedon hankinta	☐	☐
b. markkinoiden seuranta	☐	☐
c. myynnin jälkeisten palveluiden käyttö	☐	☐
d. pankkiasioiden hoito (esim. laskut)	☐	☐
e. henkilöstön rekrytointi	☐	☐
f. asiointi viranomaisten kanssa	☐	☐
g. tavaroiden tai palveluiden vastaanotto verkosta digitaalisessa muodossa (esim. tietokoneohjelmat)	☐	☐

[1] Yrityksen henkilöstön käyttöön rajattu ja suojattu Internet-teknologiaa hyödyntävä verkkopalvelu.
[2] Yrityksen ja asiakkaan tai yhteistyökumppanin valitsin Internet-teknologiaa hyödyntävä suljettu verkkopalvelu.

2.5 Kuinka suuri osa yrityksenne työntekijöistä käyttää työssään tietokonetta, josta on yhteys Internetiin?

osuus prosentteina ..... ____%

2.6 Oliko yrityksellänne Internet-kotisivut käytössä vuonna 2001 tai suunnitteilla vuonna 2002?

a. käytössä 2001 ☐
b. suunniteltu 2002 ☐
c. ei käytössä eikä suunniteltu 2002 ☐ → siirry kohtaan 3.8
d. en osaa sanoa ☐ → siirry kohtaan 3.8

2.7 Käytättekö Internet-kotisivujanne seuraaviin tarkoituksiin?

Yrityksenne Internet-palvelujen tarjoajana

	kyllä	ei
a. tuotteiden markkinointi kotisivuilla	☐	☐
b. tuotehinnastot kotisivuilla	☐	☐
c. tuotteiden sähköinen tilausmahdollisuus	☐	☐
d. tuotteiden toimitukset sähköisesti (asiakkaalla pääsy tiedostoihin tai tiedostojen / datan suorat toimitukset)	☐	☐
e. myynnin jälkeiset palvelut	☐	☐
f. asiakkailla mahdollisuus suojattuun yhteyteen	☐	☐
g. informaatiota saatavilla muilla kuin kotimaisilla kielillä	☐	☐
h. mobiililaitteilla käytettäväksi suunniteltuja sivut (esim WAP tai kämmentietokone kuten Nokia Communicator tai Palm)	☐	☐

3. Sähköinen kauppa / Internet [3]

Sähköisellä kaupalla tarkoitetaan tietokoneverkon kautta suoritettuja tavaroiden ja palvelujen tilauksia. Maksu- tai toimitustavalla ei ole merkitystä. Sähköistä kauppaa käydään esim. Internetin (tässä osio 3) tai EDIn (osio 4, seuraava sivu) kautta.

A Internet-kauppa yrityksenne kotisivujen kautta tapahtuvassa myynnissä

3.1 Oliko yrityksenne kotisivuilla vuonna 2001 palvelu, jonka kautta myitte tuotteitanne tai palvelujanne?

a. kyllä ☐
b. ei ☐ → siirry kohtaan 3.8
c. en osaa sanoa ☐ → siirry kohtaan 3.8

3.2 Oliko yrityksenne kotisivuilla vuonna 2001 palvelu, jossa yritykseltänne tilatut tuotteet tai palvelut voi maksaa suoraan kotisivujenne kautta?

a. kyllä ☐
b. ei ☐
c. en osaa sanoa ☐

3.3 Myikö yrityksenne tuotteita tai palveluja toisille yrityksille erikoistuneiden B to B Internet-markkinapaikkojen kautta vuonna 2001? [4]

a. kyllä ☐
b. ei ☐
c. en osaa sanoa ☐

3.4 Kuinka suuri oli Internet-tilausten osuus vuoden 2001 liikevaihdosta?

(Vastatkaa toiseen kohdista a tai b)

a. Internet-kaupan arvo 2001 ____ tuhatta ☐ markkaa ☐ euroa
TAI
b. arvio osuutena kokonaisliikevaihdosta. ____%

3.5 Arvioikaa yrityksenne eri asiakasryhmiltä Internetin kautta saamien tilausten osuutta yrityksenne Internetin kautta saamien tilausten kokonaisarvosta vuonna 2001.

a. yritykset	____%
b. kotitaloudet	%
c. julkinen sektori	____%
Yhteensä	= 100 %

3.6 Arvioikaa yrityksenne eri maista Internetin kautta saamien tilausten osuutta yrityksenne Internetin kautta saamien tilausten kokonaisarvosta vuonna 2001.

a. Suomi	%
b. muu EU	%
c. muut maat	____%
Yhteensä	= 100 %

[3] Valmiille sähköiselle lomakkeelle Internetissä täytetty ja lähetetty tilaus sekä varsinaisessa verkkokaupoissa tehty kauppa ovat tässä tarkoitettua sähköistä kauppaa. Tavanomaisenia sähköpostiviestinä tehdyt tilaukset eivät ole sähköistä kauppaa. Myös Ekstranetissä käyty kauppa samoin kriteerein laskotaan Internet kauppaan
[4] B to B Internet-markkinapaikalla tarkoitetaan Internetissa toimivaa palvelusivustoa, jossa kerätään yhteen paikkaan tietoja yritysten toisille yrityksille tarjoamista tavaroista tai palveluista ja jonka kautta tahot yritykset voivat neuvotella hintojen pohjalta tehdä tilauksia tarjoavilta yrityksiltä.

3.7 Internet-kaupan motivaatiotekijät.

Miten suuri merkitys seuraavilla tekijöillä oli yrityksenne päätökseen Internet-kauppaan ryhtymisestä?

	ei lainkaan	jonkin verran	suuri	en osaa sanoa
a. yrityskuva	☐	☐	☐	☐
b. kustannusten vähentäminen	☐	☐	☐	☐
c. prosessien nopeuttaminen	☐	☐	☐	☐
d. palvelun parantaminen	☐	☐	☐	☐
e. uusien asiakkaiden löytäminen	☐	☐	☐	☐
f. uusien tuotteiden lanseeraaminen markkinoille	☐	☐	☐	☐
g. kilpailussa pärjääminen	☐	☐	☐	☐
h. pääsy laajemmille markkinoille	☐	☐	☐	☐

B Internet-kauppa yrityksenne hankinnoissa

3.8 Onko yrityksessänne työtehtäviin liittyen käytetty Internetiä seuraaviin tarkoituksiin vuonna 2001?

	kyllä	ei	en osaa sanoa
a. materiaalin tai palvelujen ostaminen	☐	☐	☐
b. materiaalin tai palvelujen ostaminen erikoistuneiden B to B Internet-markkinapaikkojen kautta? [4]	☐	☐	☐

3.9 Kuinka suuri oli yrityksenne Internetissä tekemien tilausten arvo vuonna 2001? [5]

(Vastatkaa toiseen kohdista a tai b)

a. Internetissä tehdyt materiaalin ja palvelujen ostot 2001 ____ tuhatta ☐ markkaa ☐ euroa
TAI
b. arvio osuutena kaikista materiaalin ja palvelujen ostoista 2001 ____%

4. Sähköinen kauppa / EDI / OVT [6]

4.1 Oliko yrityksenne käytössä EDI vuonna 2001?

a. kyllä ☐
b. ei ☐ → siirry osioon 5
c. en osaa sanoa ☐ → siirry osioon 5

4.2 Mihin tarkoitukseen EDIä käytettiin yrityksessänne vuonna 2001?

(Useampi vaihtoehto mahdollinen)

a. tilausten vastaanotto ☐
b. tilausten tekeminen ☐
c. rahaliikenne (laskut, pankkiasiat) ☐
d. muu ☐

4.3 Kuinka suuri oli EDIn välityksellä saamienne tilausten osuus vuoden 2001 liikevaihdosta?

(Vastatkaa toiseen kohdista a tai b)

a. EDI-kaupan arvo 2001 ____ tuhatta ☐ markkaa ☐ euroa
TAI
b. arvio osuutena kokonaisliikevaihdosta ____%

4.4 Kuinka suuri oli yrityksenne EDIn välityksellä tekemien tilausten arvo vuonna 2001 [7]

(Vastatkaa toiseen kohdista a tai b)

a. EDIn välityksellä tehdyt materiaalin ja palvelujen ostot 2001 ____ tuhatta ☐ markkaa ☐ euroa
TAI
b. arvio osuutena kaikista materiaalin ja palvelujen ostoista 2001 ____%

4.5 Onko sähköisessä kaupassa käyttämänne EDI

a. EDIFACT ☐
b. XML/EDI ☐
c. muu (esim sarakemuotoinen EDI) ☐
d. en osaa sanoa ☐

[5] Tässä tarkoitetaan Internetin välityksellä tehtyjä tilauksia, jotka kirjataan tuloslaskelman kohtiin 'ostot tilikauden aikana', 'ulkopuoliset palvelut' tai 'liiketoiminnan muut kulut'. Jos vastaatte kohtaan b, arvio tehdään osuutena edellä mainituyn tuloslaskelman kohtien summasta.
[6] EDI/OVT (Electronic Data Interchange / Organisaatioiden välinen tiedonsiirto) on menettely, jossa asiakirja korvataan yrityksen tietojärjestelmässä sijaitsevista tiedoista tuotetulla määrämuotoisella sanomalla, joka välitetään sähköisesti vastaanottavaan yritykseen ja purotaan siellä automaattisesti suoraan tietojärjestelmään (esim. tilaus, laskun maksusoitto pankkiin, hinnasto tai tuoteluettelo).
[7] Tässä tarkoitetaan EDIn välityksellä tehtyjä tilauksia, jotka kirjataan tuloslaskelman kohtiin 'ostot tilikauden aikana', 'ulkopuoliset palvelut' tai 'liiketoiminnan muut kulut'. Jos vastaatte kohtaan b, arvio tehdään osuutena edellä mainituyn tuloslaskelman kohtien summasta.

5. Sähköinen kauppa / tietojärjestelmät

Jos yrityksenne ei tee sähköistä kauppaa Internetin tai EDIn välityksellä siirtykää osioon 6.

Onko sähköisen kaupan järjestelmänne integroitu seuraaviin tietojärjestelmiin tai prosesseihin?

	EDI kyllä	Internet kyllä	ei	en osaa sanoa
a. asiakasrekisteri	☐	☐	☐	☐
b. tavaran tai palvelujen tuotanto	☐	☐	☐	☐
c. tavaran tai palvelujen toimitus	☐	☐	☐	☐
d. jatkotilaukset tavarantoimittajilta	☐	☐	☐	☐
e. laskutus ja maksujärjestelmät	☐	☐	☐	☐

6. Internet-kauppaan liittyvät ongelmat

Arvioikaa mahdollisten ongelmien merkitystä Internet-kaupallenne tai sen aloittamiselle

	ei lainkaan	jonkin verran	suuri	en osaa sanoa
a. yrityksen tuotteet eivät sovellu myyntiin Internetissä.	☐	☐	☐	☐
b. asiakaspotentiaali liian pieni	☐	☐	☐	☐
c. asiakkaat eivät ole valmiita Internet-kauppaan	☐	☐	☐	☐
d. epävarmuus maksuliikenteessä	☐	☐	☐	☐
e. epävarmuus oikeudellisista kysymyksistä (kuluttajasuoja, takuut yms.)	☐	☐	☐	☐
f. logistiikkaan liittyvät ongelmat	☐	☐	☐	☐
g. liian suuret käyttöönotto-/ylläpitokustannukset	☐	☐	☐	☐
h. painopiste nykyisissä myynti- /jakelukanavissa	☐	☐	☐	☐
i. muita ongelmia – mitä?				

7. Internetin käyttöön liittyvät ongelmat

Arvioikaa mahdollisten ongelmien merkitystä Internetin käytössä tai sen käyttöön ottamisessa yrityksessänne

	ei lainkaan	jonkin verran	suuri	en osaa sanoa
a. tietoturvaongelmat / virusvaara	☐	☐	☐	☐
b. teknisesti liian monimutkaista	☐	☐	☐	☐
c. tekniikan tai tietokoneohjelmien kustannukset	☐	☐	☐	☐
d. kotisivujen kehittämisen ja ylläpidon kustannukset.	☐	☐	☐	☐
e. liian suuret tietoliikennekulut	☐	☐	☐	☐
f. menetetty työaika (työhön liittymätön käyttö)	☐	☐	☐	☐
g. tietoliikenteen hitaus / epävarmuus	☐	☐	☐	☐
h. Internetistä on liian vähän hyötyä odotettavissa yritykselle	☐	☐	☐	☐

8. Tausta- ja yhteystiedot

Liikevaihto 2001 (tai arvio)	____ tuhatta ☐ markkaa ☐ euroa	
Tuloslaskelman kulut yhteensä vuonna 2001 (tai arvio)	Lasketaan kohdista: ostot tilikauden aikana + ulkopuoliset palvelut + liiketoiminnan muut kulut	
Vain yritykset jotka ovat tehneet hankintoja Internetin tai EDIn välityksellä vastaavat	____ tuhatta ☐ markkaa ☐ euroa	
Yhteyshenkilö yrityksessä		
Puhelinnumero		
Sähköpostiosoite		
Kommentteja		

Kiitos vastauksestanne!

A. AINEELLISEN KÄYTTÖOMAISUUDEN JÄLLEENHANKINTA-ARVO JA KÄYTTÖIKÄ 2002

Återanskaffningsvärdet på och livstiden för materiella anläggningstillgångar

Käyttöomaisuusryhmä *Anläggningsgrupp*	Jälleenhankinta-arvo vuoden lopussa *Återanskaffningsvärde vid årets slut* **1000 Euroa** ***1000 Euro***	Keskimääräinen ikä vuoden lopussa *Genomsnittlig ålder vid årets slut* **Vuotta** ***år***	Arvioitu jäljellä oleva käyttöikä *Uppskattad återstående livstid* **Vuotta** ***år***	Keskeisten uushankintojen odotettavissa oleva käyttöikä *Förväntad återstående livstid för centrala nyanskaffningar* **Vuotta** ***år***
1. Rakennukset (ei asuinrakennukset) *Byggnader (inte bostadsbyggnader)*				
1.1 Rakennukset, jotka omistetaan itse *Byggnader, som ägs själv*				
1.2 Rakennukset, jotka ovat vuokrattuina käytössä *Byggnader, som används uthyrda*				
2. Maa- ja vesirakennukset *Jord- och vattenbyggnader*				
3. Kuljetusvälineet *Transportmedel*				
4. Koneet, laitteet ja kalusto yhteensä *Maskiner, anordningar och inventarier, totalt*				
4.1 Toimistotietokoneet (sisältäen ohjelmistot) ja niiden oheislaitteet *Kontorsdatorer (inkl. programvara) okringutrustning*				
4.2 Tietokoneohjatut tuotantolaitteet *Datorstyrda produktionsanordningar*				
4.3 Muut tuotantolaitteet *Övriga produktionsanordningar*				
4.4 Muut koneet, laitteet ja kalusto *Övriga maskiner, anordningar och inventarier*				

B. TIETOTEKNIIKAN KÄYTTÖ TUOTANNOSSA

Användning av datateknik i produktionen

Rasti ruutuun myönteisessä tapauksessa – *Markera i rutan det som gäller:*

	Numeerisesti ohjatut työstökoneet *Numeriskt styrda verk tygsmaskiner* (NC)	Tietokone-avusteinen suunnittelu *Datorstödd konstruktion* (CAD)	Tietokone-avusteinen valmistus *Datorstödd produktion* (CAM)	Tietokoneohjatut tuotantoprosessit *Datorstyrda produktions-processer*	Joustavat tuo-tantojärjestelmät *Flexibla produktions-system* (FMS)	Robotit *Robotar*	Muu sovellus *Annan tillämpning*
Käytämme tällä hetkellä *Vi använderför närvarande*	☐	☐	☐	☐	☐	☐	☐
Aiomme ottaa käyttöön *Vi planerar att ta i bruk*	☐	☐	☐	☐	☐	☐	☐

Muu tietotekninen sovellus, lyhyt kuvaus – *Annan datateknisk tillämpning, kort beskrivning :*

ENDNOTES

[1] We have ignored the roles of entry and exits for two reasons. More detailed investigations performed by linking ICT data with the Business Register indicated that only few firms in the ICT data are true entries and exits. Measurement of the entry and exit effects would be then highly unreliable. Besides, true entries and exits account for an insignificant labor share, a few percentages altogether (see Ilmakunnas & Maliranta, 2003). Both entry and exit should be seen as time-consuming events and therefore restructuring takes place essentially among the continuing firms (and their plants).

[2] This is necessary, because services flows of computer network investments are unavailable.

[3] Ratio of non-production workers to employment.

[4] Three employment-based variants are considered.

[5] The necessary instrument is derived by specifying a Probit selection equation for adopting a computer network.

[6] The 1988–97 growth in relative labor productivity or market share of a plant.

[7] All modeled as variable, as opposed to quasi-fixed, inputs.

[8] Data on organizational practices and labor force characteristics originate form the authors' cross-sectional survey conducted in 1995–96. IT measures are from Computer Intelligence Infocorp (1987–94) and remaining data is from Compustat (1987–94).

[9] A further alternative would be to specify the firm's ICT stock (proxied, *e.g.*, by the number of computers in use, which could be calculated from the data at our disposal by multiplying the computer intensity by employment) as an additional factor of production in (3) or derive the ICT's share in the overall capital stock and proceed as we have done with the labor share of ICT-equipped labor.

[10] Note, however, that our controls include interacted two-digit industry and annual time dummies which would necessarily capture some of this effect.

[11] However, the tendency of ICT being more productive in younger firms weakens in unweighted results.

[12] In the Table below (only the ICT indicator coefficient estimates are reported) we have re-estimated manufacturing Column 2 in Table 5 with all possible combinations of the following:
- Weighted / non-weighted,
- With / without constant returns to scale imposed,
- Identically independently distributed (homoskedastic, no autocorrelation, non-robust) / robust / fully robust standard errors,
- With only the constant term (No) / only industry dummies (Ind.) / only time dummies (Time) / industry and time dummies (Ind.+Time) / interacted industry and time dummies (Ind.*Time).
- The alternative reported in the text is marked with a rectangle.

Options			Dummies				
Weighted	Constant	Robust	No	Ind.	Time	Ind.+Time	Ind.*Time
No	No	No	0.251***	0.164***	0.246***	0.154***	0.151***
No	No	Yes	0.251***	0.164***	0.246***	0.154***	0.151***
No	No	Yes, fully	0.251***	0.164***	0.246***	0.154***	0.151**
No	Yes	No	0.298***	0.208***	0.284***	0.191***	0.189***
No	Yes	Yes	0.298***	0.208***	0.284***	0.191***	0.189***
No	Yes	Yes, fully	0.298***	0.208***	0.284***	0.191***	0.189***
Yes	No	No	0.237***	0.097**	0.223***	0.076*	0.089*
Yes	No	Yes	0.237***	0,097	0.223***	0,076	0,089
Yes	No	Yes, fully	0.237***	0,097	0.223***	0,076	0,089
Yes	Yes	No	0.233***	0.088*	0.222***	0,072	0.093*
Yes	Yes	Yes	0.233***	0,088	0.222***	0,072	0,093
Yes	Yes	Yes, fully	0.233***	0,088	0.222***	0,072	0,093

As can be seen in the above table, the largest and most significant ICT coefficient estimates are reached with no or only time dummies. The smallest and lest significant coefficient estimates reached with both industry and time dummies. Weighting reduces the significance of the coefficient estimates. Robust standard errors reduces the significance of the coefficient estimates (slightly higher for fully robust than robust). Coefficient estimates are higher and more significant with constant returns to scale imposed.

[13] Due to the data confidentiality laws the identity of firms has been hidden from us. We have not identified *Nokia* from the sample and we are unaware whether it is included or not in the ICT survey(s).

[14] In any case fixed T and large N asymptotics are valid for arbitrary time dependence and heterogeneity across t.

[15] Structural changes have been particularly numerous and intense among Finnish firms in the 1990s as compared to both other countries and earlier history. This is likely to weaken both the amount and the accuracy of within firms variation in our legal unit -based firm data. One option would be to make use establishment-firm links in order to produce 'filtered' or 'synthetic' firm units for the analysis.

[16] In the case of the ICT indicators, the 'between' variation (std. dev.) is from three and a half to seven and a half times larger than the 'within' variation.

[17] Note that the industry–time dummies already control for *all* industry-level variation.

[18] See, e.g., Wooldridge (2002, pp. 83-4, 92, 105): (1) IVs must be partially correlated with the variable to be instrumented once the other exogenous variables are netted out. Tested by regressing the variable to be instrumented on all exogenous variables and IVs. IVs are individually and jointly significant at conventional levels. (2) IVs must be redundant in the model. Tested by estimating the model with the IVs included as regressors. IVs are individually and jointly insignificant. (3) IVs must be uncorrelated with the error term. Cannot be tested precisely, as the true coefficient estimates are unobserved. We nevertheless study the correlation with the OLS residuals and found no evidence for it.

[19] Also from a technical point of view we report the lower bound estimates, *i.e.*, we report $\theta_{L_{ICT}}$ rather than $\beta_L \theta_{L_{ICT}}$.

[20] Authors' interpretation of Dirk Pilat's (OECD) presentation in 10 April 2003 at the Ministry of Trade and Industry in Helsinki.

[21] This is not necessarily an unreasonable assumption in micro-level work.

[22] Note that the logic in the naming of the surveys has changed.

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