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FIRM GROWTH AND PROFITABILITY: THE ROLE OF MOBILE IT AND ORGANIZATIONAL PRACTICES

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ABSTRACT: This study uses a unique survey data from 398 Finnish manufacturing firms to explore how the order of magnitude of mobility and connectivity of a firm's ICT stock in conjunction with various organizational innovation and HRM practices affect the firm's performance. The data suggest that mobile connectivity as such does not significantly contribute to the firm's growth and profitability. However, the empirical results find support for the agency theory based argument: a greater mobility associated with the use of a pertinent economic incentive scheme and a systematic performance monitoring seems to promote the firm's growth. In addition, re-organization of tasks within an organization is implemented most successfully, boosting profitability, when the firm's re-organization strategy incorporates the adoption of mobile, Internet-connected IT stock.

JEL Classification: L25, M52, M54, O33

KEY WORDS: ICT use, mobility, connectivity, organizational practices, firm performance

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TIIVISTELMÄ: Tämän tutkimuksen päämääränä on selvittää sitä, kuinka yrityksen tieto- ja viestintäteknologian liikkuvuus ja liitettävyys yhdessä organisatoristen innovaatiotoimintaa ja henkilöstönhallintaa koskevien toimintatapojen kanssa vaikuttavat yrityksen suorituskykyyn. Ainutlaatuinen 398 suomalaista teollisuusyritystä koskeva kyselyaineisto viittaa siihen, ettei kannettavien tietoliikenneyhteyksin varustettujen tietokoneiden osuudella itsessään ole merkittävää vaikutusta yrityksen kasvuun ja kannattavuuteen. Empiirisen analyysin tulokset tukevat kuitenkin agenttiteoriaan perustuvaa argumenttia: tietoliikenneyhteyksien suurempi liikkuvuus yhdistettynä sopiviin taloudellisiin kannustinmekanismeihin ja systemaattiseen tulosseurantaan näyttää lisäävän yrityksen kasvua. Myös tehtävien uudelleenorganisointi organisaation sisällä tuottaa parhaita, yrityksen kannattavuutta kasvattavia tuloksia niissä yrityksissä, joissa on otettu myös käyttöön laajempi kannettava, Internet-yhteyksin varustettu tietokonekanta.

AVAINSANAT: tieto- ja viestintätekniikan käyttö, liikkuvuus, liitettävyys, organisatoriset toimintatavat, yrityksen suorituskyky

1. Introduction

Investments in general purpose technologies such as information and communications technologies (ICT) as such may have a rather limited contribution to a firm's economic performance as the full benefits from ICT adoption tend to materialize only if the firm also implements certain complementary organizational changes (see, e.g, Brynjolfsson and Hitt, 2000). The literature presents extensive empirical evidence on the firm-level performance impacts of information technology (IT) investments generally but very few studies explicitly shed light on the economic consequences of *mobility* and *connectivity* of a firm's IT stock. This empirically oriented study focuses on the role of mobile IT in conjunction with various organizational innovation and human resource management (HRM) practices in promoting the firm's performance.

Economic theory gives grounds for believing that the order of magnitude of portability and connectivity of the firm's IT equipment closely relates to a firm's organization, innovation behavior, and further contribute to the firm's performance. The agency theory based argument of this study is that the economic incentive mechanisms may push managers and employees to work harder also off-site (e.g. during business trips or at home) particularly when they have access to mobile and Internet-connected IT. Transaction costs theory is also relevant in this context: the use of Internet-connected IT can substantially reduce a firm's transaction costs as it enables efficient coordination, management and use of information. Mobile, Internet-connected IT may further lower transaction costs as it provides also off-site access to the firm's internal database and other relevant sources of information.

This study employs a unique survey data collected from 398 Finnish manufacturing firms in September 2005 combined with financial statistics of the sample firms to shed light on the performance implications of the firms' ICT use and organizational practices. We measure a firm's performance by sales growth and profitability. The following four variables capture the

firm's use of ICT: the share of a firm's employees using i) solely a desktop with no access to Local Area Network (LAN) ii) a laptop with no access to LAN, iii) solely a desktop with an access to LAN, and iv) a laptop with an access to LAN.

Our empirical analysis strongly suggests that mobile connectivity does matter. A large mobile IT stock with an access to the Internet does not benefit the organization without the implementation of certain other organizational or HRM practices though. We find that greater mobile connectivity has benefited most those firms undertaking a major re-organization of work and firms employing performance based wage scheme in conjunction with a systematic performance monitoring. It also seems that a relatively greater Internet-connected IT stock eminently improves the performance of the firms outsourcing their activities.

The rest of the paper is organized as follows. Section 2 first provides some descriptive observations on the Finnish manufacturing firms' ICT use, and then discusses the conceptual framework of the relationship between ICT use, organizational factors and a firm's performance. Transactions costs economics and agency theory are particularly relevant for the hypothesis formation in the context of this study. Section 2 also introduces the explanatory variables of the econometric analysis. Section 3 presents the econometric model and reports the estimation results. Section 4 concludes the paper.

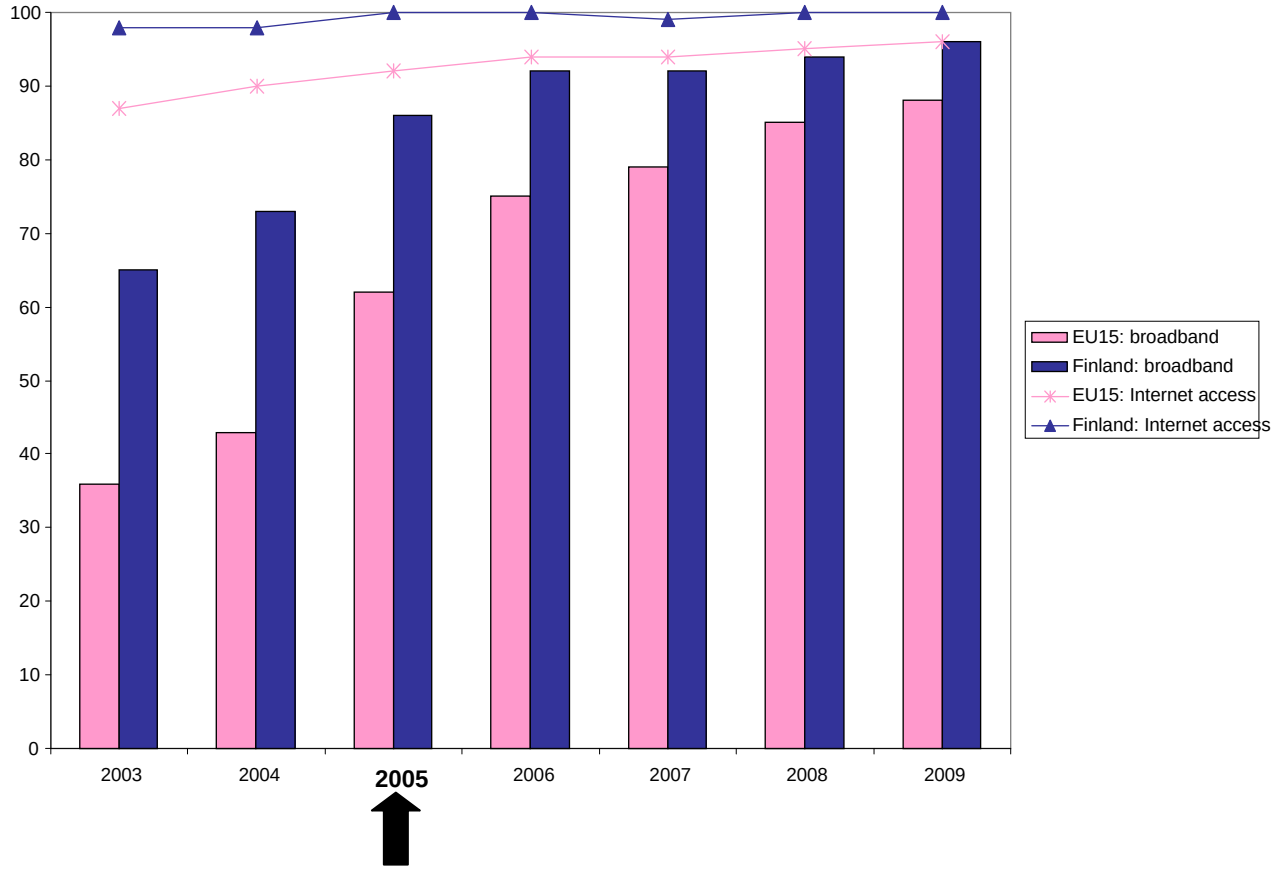
2. ICT, mobility and firm performance

2.1 Descriptive observations on firms' ICT use

The empirical analysis reported in this paper uses a survey data collected via telephone interviews from the Finnish manufacturing firms (i.e. TOL 2002 categories 15-37, based on SIC/NACE 2002 classification) employing 50 or more persons in Statistics Finland's business register. The data were collected in September 2005 from 398 firms, covering about 38% of

the total population of 1,054 firms.[1] Jones et al (2008), using the same data, show that the sampled manufacturing firms represent well the total population of the Finnish manufacturing firms in terms of industry and size. The survey data was combined with the Asiakastieto[2] financial data concerning the sampled firms.

Figure 1. Manufacturing firms (employing 10 or more persons) with Internet and broadband access, 2003-2009: EU-15 countries vs. Finland



Data source: Eurostat, Information Society Statistics
(http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database)

The Eurostat statistics shows that the Finnish manufacturing firms have been among the advanced adopters of technologies enabling access to the Internet (Figure 1). The penetration rate of Internet access among the Finnish manufacturing enterprises employing 10 or more persons was 100 percent in 2005, the sample year of our firm-level data, while the corresponding average among the manufacturing firms of all EU-15 countries was 92 percent. In 2005, 88 percent of the Finnish

[1] See Jones et al. (2008) for a detailed description of the data collection procedure.
[2] Asiakastieto is a Finnish company that collects, maintains and sells firm-specific financial and credit information.

manufacturing firms accessed the Internet via broadband. The manufacturing companies of the EU-15 countries reached the same broadband access rate in 2009, while in 2005, slightly over 60 percent of them had a broadband connection to the Internet.

Our analysis focuses on the ICT use of sample manufacturing firms in 2005 (see Figure 2). The share of a firm's employees using laptops varied between 0 and 80 percent, while the average was relatively low, about 10 percent. The percentage of a firm's employees using a computer, either desktop or laptop, on a daily basis varied between 10 and 100 percent among the sample firms, while the average was about 58 percent.[3]

Figure 2. ICT use of sample manufacturing firms in 2005: share of firms' employees using desktops and laptops with and without a LAN connection

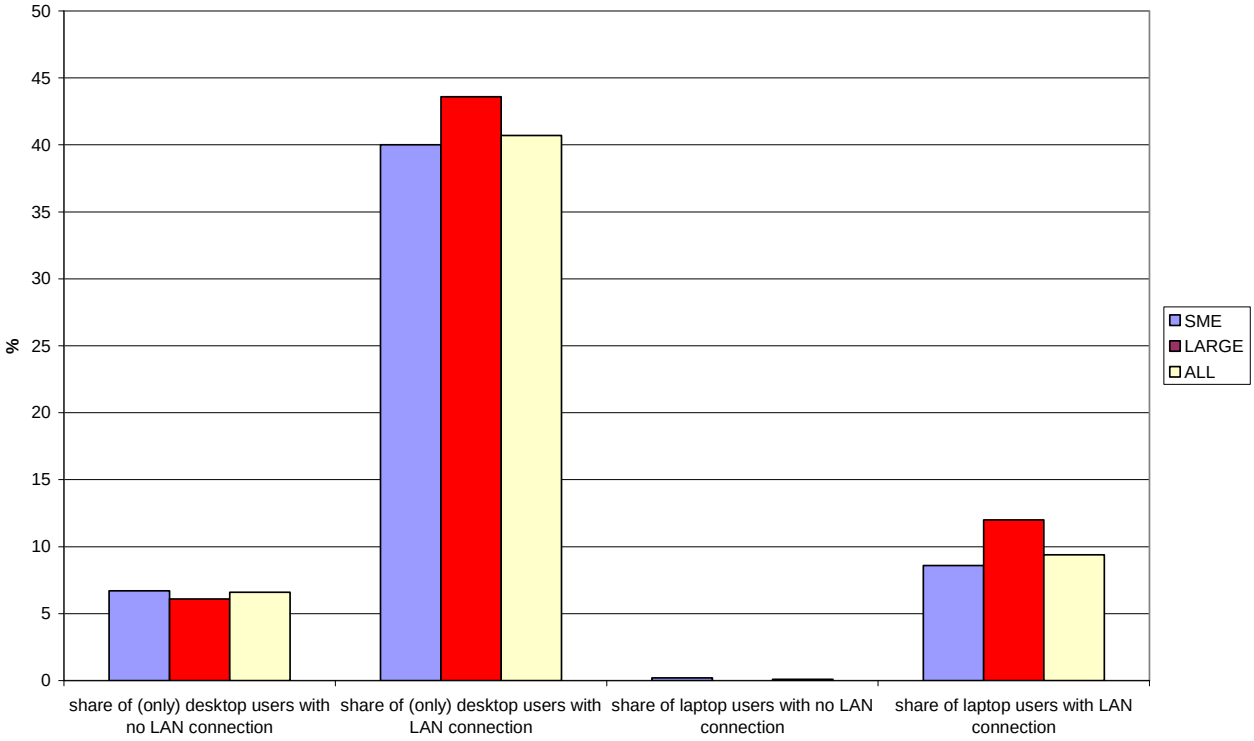


Figure 2 illustrates the shares of the sample firms' employees using desktops and laptops with and without access to the Internet. The survey data reveal the percentage of all employees

[3] According to Eurostat's Information Society Statistics, in 2005, the share of employees in the Finnish manufacturing firms (with 10 employed people or more) using a computer *at least once a week* was, on average, 66 percent (http://epp.eurostat.ec.europa.eu/portal/page/portal/information_society/data/database).

using (on a roughly daily basis) a computer, either desktop or laptop, connected to the LAN. We apply this percentage to approximate both the shares of Internet-connected desktop and laptop users[4]. About 86 percent of the firms' computer users, on average, had a LAN connection. In 75 percent of the cases, all of the firm's employees using a computer on a daily basis had also a LAN connection.

Clearly, the majority of the firms' computer users are having only a desktop, and most of them have access to the Internet. Slightly over 5 percent of the employees using merely a desktop at work and only a very small portion of the laptop users had no LAN connection. The t-test indicates that the difference in the shares of a firm's employees using desktops with or without LAN access is not statistically significant between SMEs and large firms. However, a statistically significantly higher (at $p<0.01$) share of employees of large firms used an Internet-connected laptop compared to SMEs. This finding is consistent with various previous empirical studies suggesting that larger firms tend to be earlier adopters of advanced technologies.

2.2 Conceptual framework with introduction to data

Empirical studies published since the mid 1990s have convincingly argued that IT is a general purpose technology that facilitates complementary innovations, and further that the performance gains from IT for firms closely relate to the implementation of complementary organizational practices or changes (see, e.g., Brynjolfsson and Hitt, 1997, 2000; Bresnahan et al., 2000; Murphy, 2002; Gera and Wu, 2004; Koellinger, 2008). The empirical study of Brynjolfsson and Hitt (1998) is among the first systematic empirical analysis reporting a positive relationship between a firm's computer use (measured by IT capital stock) and productivity. This empirical study, as well as the literature review of the same authors

[4] In other words, we make an assumption that the portable and non-portable IT stocks have similar Internet access rates within a firm. This assumption is certainly correct for at least 75 percent of sample firms, i.e. the share of firms in which all computer users had a LAN connection.

(Brynjohlfsson and Hitt, 2000) concludes that the interaction with a firm's IT capital and its organizational practices plays a substantial role in the materialization of the benefits from the firms' IT investments.

Previous empirical studies have generally not explicitly considered the role of mobility and the connectivity of the firm's IT stock. There are few exceptions though. The empirical exploration of Maliranta and Rouvinen (2006) uses ICT survey data from the Finnish companies for the year 2001, and finds a positive relationship between mobility and connectivity of a firm's ICT stock and labor productivity. The reported findings of this study base, however, on data comprising no information about magnitude of connectivity within the firm, just whether the firm has access to the Internet via wireless or wireline connection. Rawley (2006) explores how the adoption of mobile IT networks affects firm performance in the U.S. taxicab industry. His study suggests that the adoption of mobile IT networks enhances the taxi companies' productivity. Neither of these studies considers the role of (complementary) HRM practices and their impact on the firm's performance.

Economic theory gives grounds for believing that order of magnitude of portability and connectivity of the firm's ICT equipment may matter. Particularly relevant for the hypothesis formation in this context are transactions costs economics and agency theory.

Transaction costs theory suggests that a firm's performance relates closely to the order of magnitude of its transaction costs such as search and information costs and other costs related to decision-making. An increase in the number of computers connected to the Internet has a great potential to reduce a firm's transaction costs as it enables efficient coordination, management and use of information. It seems credible though that the managers make many business decisions off-site, for instance, during the business trips. Then, access via a portable device to the firm's internal database or other relevant source of information may provide substantial benefits and further reduce transactions costs. Our hypothesis is thus that the share

of a firm's employees using roughly on a daily basis a computer, particularly laptops, with the Internet connection positively relates to the firm's performance.

Outsourcing is likely to increase, ceteris paribus, a firm's costs related to its transactions as outsourcing often involves substantial information costs as well as costs arising from setting up and maintaining the outsourcing contract. The possibilities of the ICT to lower transaction costs of outsourcing are substantial (e.g., via electronic data interchange between the trading partners), and thus the use of Internet-connected IT stock is likely to increase the net benefits for a firm from outsourcing. Therefore, our hypothesis is that the interaction terms between the variables measuring the shares of a firm's employees with Internet-connected laptops and desktops and the dummy variable OUTSOURCE that gets value 1 if the firm has outsourced its activities during the past three years, and 0 otherwise, positively relate to the firm's performance.

Agency theory focusing on incentives between a firm's owners and managers/employees (Grossman and Hart, 1986) also provides a relevant conceptual framework for our analysis. Firms use various different economic incentive schemes such as option schemes, performance-based payment, and stock ownership of a firm's management/employees to align the incentives of owners and managers and employees. A successful implementation of these schemes should enhance firm performance. Our argument is that the incentive mechanisms may push managers and employees to work harder also when they are off-site (e.g., during the business trips) when they have access to mobile and Internet-connected IT devices.[5] Our hypothesis is thus that the implementation of economic incentive mechanisms combined with a higher share of a firm's employees using laptops with access to the Internet relates positively to the firm's sales growth and profitability.

There is also an extensive **organizational economics** literature that links organizational innovation and HRM practices directly to the firm's performance (see, e.g., Bloom and Van

[5] According to Information Society Statistics of Eurostat, 35 percent of the Finnish manufacturing firms in the sample year of 2005 had employees working part of their time away from enterprise.

Reenen, 2007; Jones et al, 2008; Koski et al., 2008). Bloom and Van Reenen (2007) conclude that the implementation of best managerial practices strongly associates with firms' better performance in terms of their profitability, sales growth, Tobin's Q, productivity and firm survival. Two previous studies using the same survey data as our study also find a linkage between a firm's organizational practices and performance. Jones et al. (2008) investigate the relationships between the use of various HRM practices and productivity, and find that only the adoption of performance based wages – which they call a profit-sharing scheme - and use of consultative committee statistically significantly contribute to the firm's productivity. Koski et al. (2008) further find that the implementation of performance based wages combined with a systematic monitoring of a firm's performance and the ownership of a firm's stocks by the employees and/or managers enhance innovation.

We control for the different organizational and HRM practices with the set of variables that describe i) re-organization of work, ii) use of incentive pay mechanisms, iii) employee participation, iv) quality control and monitoring within a firm.

i) Re-organization of work: The adoption of new information and communications technologies tends to have implications for firm organization and work practices.[6] Our survey data comprise information on the share of tasks a firm has substantially re-organized after the beginning of the year 2002. On average, the respondents reported that the firm had re-organized one fifth of their tasks during the past three years.[7] The variable WORK_REORG measures the percentage of tasks a firm had reorganized since the beginning of 2002.

[6] For instance, Bresnahan et al. (2000) found that the greater IT intensity relates to increased delegation of authority to individual and teams.

[7] In those firms in which a higher than average share of employees used merely a desktop with or without the LAN connection or a laptop without the LAN connection, the order of magnitude of re-organization of work didn't differ statistically significantly – according to the t-test – from the other companies. Instead, work re-organization seems to correlate more closely with the use of mobile IT. The firms with a higher than the average share of employees using an Internet-connected laptop had substantially re-organized 25 percent of their tasks within the past three years, while the corresponding percentage was about 17 among the other firms. A t-test indicates that this difference is also statistically significant

ii) Incentive pay mechanisms: Firms generally adopt incentive pay mechanisms to motivate employees to produce better performance. We control for various incentive pay schemes by a set of dummy variables that get value 1 if the incentive mechanism is in use, and 0 otherwise: whether a firm employs a performance based wage system (the variable PERFORM_PAY), and whether a firm uses an option scheme for the management or the personnel in general (the variable OPTION_SCHEME). The ownership of a firm's stocks may also provide a mechanism aligning the employees/management incentives with the (other) owner's of the firm. The variable STOCK_OWNED_EMPL, that gets value 1 if the firm's employees and/or management own the firm's stocks, controls for this.

iii) Employee participation: The variable EMPL_PARTICIP_FREQ measures the frequency or the order of magnitude of employee participation in the firm's decision-making. It is a sum of two variables, the number of developing discussions held between managers and employees per year and the number of firm-level decisions that involve joint planning or joint decision making with the employees. Such decisions are grouped in the questionnaire into seven decision making categories concerning business strategies, major organizational changes such as mergers, adoption of new technologies or equipment, the reduction of the firm's personnel, work safety, employee education, and the economic incentive mechanisms**.** We also control for job rotation (the dummy variable JOB_ROTATION) as it seems possible that employee learning related to job rotation will contribute to the firm's performance.

iv) Quality and monitoring: It is also interesting whether those firms implementing organizational practices used for fostering and controlling the quality of a firm's products and for monitoring the firm's performance reach higher performance than others do. We measure organizational practices focusing on quality improvements by the dummy variable QUALITY that gets value 1 if a firm uses quality circles, the total quality management (TQM) system, or the quality management system based on ISO9000 standard, and 0 otherwise.

It seems further likely that the use of advanced tools for systematically monitoring a firm's performance may reduce agency costs and helps to align incentives of the firm's owners and managers/employees. The degree of monitoring is captured by the variable MONITOR that takes value 1 if a firm uses balanced scorecard (or other similar tools that monitor a firm's performance against its strategic goals) or benchmarking comparison[8] to monitor the firm's performance, and 0 otherwise. It seems credible that a systematic performance monitoring gives performance incentives for a firm's employees especially if their salary is tied to the firm's performance. The dummy variable MONITOR_PERF_PAY gets value 1 if the firm uses the performance based wage system, monitors firm performance using balanced scorecard or benchmarking comparison, and further reports the performance outcome to the employees.

Table 1: Description of the variables

Description of variable	Variable name	# obs	Mean	Std. Dev.	Min	Max
Dependent variables:						
A firm's return on assets in 2005 (%).	PROFITABILITY	382	0.10	0.15	-0.51	1.12
The percentage change of a firm's sales revenues between the years 2004 and 2005.	GROWTH	377	0.10	0.25	-0.51	2.07
Explanatory variables:						
Share of a firm's employees using a desktop on (roughly) daily basis without LAN access.	DESKTOP	383	0.07	0.16	0	0.9
Share of a firm's employees using a laptop without LAN access.	LAPTOP	383	0.00	0.01	0	0.08
PC+LAPTOP	COMPUTER	383	0.07	0.16	0	0.9
Share of a firm's desktop users having a Local Area Network (LAN) access.	DESKTOP_LAN	383	0.41	0.27	0	1
Share of a firm's desktop users using a desktop on (roughly) daily basis and having LAN access.	LAPTOP_LAN	383	0.09	0.12	0	0.8
Dummy variable that gets value 1 if firm has outsourced its activities during the past three years, 0 otherwise	OUTSOURCE	396	0.49	0.50	0	1
Share of a firm's tasks that have been substantially re-organized during the past three years.	WORK_REORG	352	0.20	0.23	0	1

[8] Benchmarking comparison means that a firm collects quantitative and qualitative data from its practices and performance, and compares them against other similar (in terms of, e.g., size and industry) firms, typically those applying "best practices" in the industry.

Sum of two variables: number of developing discussions held between managers and employees per year and number of firm-level decision categories out of seven (decision making concerning firm's business strategies, major organizational changes such as mergers, adoption of new technologies or equipment, reduction of personnel, work safety, employee education, economic incentive mechanisms**)** requiring joint planning or joint decision making with employees.	EMPL_PARTICIP_ FREQ	395	4.08	1.89	0	9
Dummy variable that gets value 1 if firm uses job rotation, 0 otherwise	JOB_ROTATION	398	0.83	0.37	0	1
Dummy variable that gets value 1 if firm uses performance based wage system, and 0 otherwise.	PERFORM_PAY	398	0.67	0.47	0	1
Dummy variable that gets value 1 if firm uses an option scheme for the total management/personnel, 0 otherwise.	OPTION_SCHEME	397	0.09	0.29	0	1
Dummy variable that gets value 1 if the firm's employees and/or management own the firm's stocks, and 0 otherwise.	STOCK_OWNED_ EMPL	370	0.54	0.50	0	1
Dummy variable that gets value 1 if firm uses quality circles, total quality management (TQM) system, or quality management system based on ISO9000 standard, and 0 otherwise.	QUALITY	398	0.86	0.35	0	1
Dummy variable that gets value 1 if firm uses balanced scorecard (or other similar tool) or benchmarking comparison to monitor the firm's performance, and 0 otherwise.	MONITOR	398	0.80	0.40	0	1
The dummy variable that gets value 1 if firm uses balanced scorecard or benchmarking comparison to monitor the firm's performance, informs employees about the achieved performance, and uses performance based wages, and 0 otherwise.	MONITOR_ PERFORM _PAY	398	0.52	0.50	0	1
Log firm's R&D expenditures per employee.	RD	398	4.99	1.00	0.00	8.57
Log firm's age.	AGE	398	2.54	0.77	0.01	4.60
Dummy variable that gets value 1 if a firm has 50-99 employees, and 0 otherwise.	EMPL_50-99	398	0.42	0.49	0	1
Dummy variable that gets value 1 if a firm has 100-199 employees, and 0 otherwise.	EMPL_100-199	398	0.23	0.42	0	1
Dummy variable that gets value 1 if a firm has 200-499 employees, and 0 otherwise.	EMPL_200-499	398	0.19	0.39	0	1
Dummy variable that gets value 1 if a firm has 500-999 employees, and 0 otherwise.	EMPL_500-999	398	0.10	0.30	0	1
Dummy variable that gets value 1 if a firm has over 1000 employees, and 0 otherwise.	EMPL_OVER1000	398	0.04	0.18	0	1
Dummy variable that gets value 1 if a firm's owner is domestic family or individual owning over 50 percent of the firm, and 0 otherwise.	FAMILY_OWN	396	0.30	0.46	0	1
+ Interaction terms with IT use and organizational factors						
+ Industry dummies (at the 2-digit level using NACE 1.1 industrial classification)						

Control variables: We also control for certain firm-specific factors that the previous literature relates to the firm-level performance differences: firm age (the variable AGE) and size (a set of SIZE dummies, see Table 1 for further details). Innovation is often argued to be a major driver of a firm's growth and profitability though not all previous empirical studies fully support this argument (see, e.g., Koellinger, 2008)[9]. We capture the firm-specific differences in innovation activities by the variable RD that is a (log) firm's R&D expenditures per employee. Various previous studies also suggest that a firm's ownership structure may influence for its performance, and particularly that active family control is associated with higher profitability (see, e.g., Maury, 2006). We use the dummy variable FAMILY-OWN to control for companies owned an individual or family with over 50 percent ownership share of the firm. The industry-specific variation in market conditions and opportunities for growth is further controlled by the set of industry dummy variables (using the 2-digit standard industrial classification, SIC, level for the formulation of the industry dummies).

3. Empirical findings

We use the following two variables – the first capturing a firm's growth and the second its profitability – for measuring the dependent variable of the estimated equation, the firm's performance (PERFORMANCE): i) sales revenue growth and ii) return on assets. We first estimate an econometric model assuming that the IT stock independently on the organizational practices affects only directly a firm's performance:

$$PERFORMANCE_i = \alpha_0 + \sum_j \alpha_j IT_{ij} + \sum_k \alpha_k ORG_{ik} + \sum_l \alpha_l CONTROL_{il} + \varepsilon_i \quad (1)$$

[9] For instance, Koellinger (2008) finds in his empirical studu that innovative activity is positively related to firm growth but not necessarily associate so strongly with higher profitability.

Subscript *i* above refer to firm-specific observations, and ε denote the error term of the estimated equation. The term IT denotes a vector of IT-specific variables: the share a firm's employees using i) only a desktop without LAN connection (variable DESKTOP), ii) only a desktop with LAN connection (variable DESKTOP+LAN), iii) a laptop without LAN connection (variable LAPTOP), and iv) a laptop with LAN connection (variable LAPTOP+LAN). The vectors ORG and CONTROL comprise, respectively, the sets of *k* organizational practices and *l* control variables potentially affecting a firm's performance (see discussion above).

The second estimated econometric model includes a third set of explanatory variables, i.e. the interaction terms of the vectors IT and ORG. It captures the relationship between a firm's ICT use, its implementation of a set of organization practices, and their interaction as follows:

$$PERFORMANCE_i = \alpha_0 + \sum_j \alpha_j IT_{ij} + \sum_k \alpha_k ORG_{ik} + \sum_m \alpha_m ORG * IT_{im} \sum_l \alpha_l CONTROL_{il} + \varepsilon_i \quad (2)$$

We employ the ordinary least squares (OLS) technique with the White's (1980) heteroscedasticity consistent standard errors.[10] As the shares of the firms' employees using a laptop without Internet connection are very small, close to zero, the use of the interaction terms of the organizational variables and the variable LAPTOP generates multicollinearity problem. We therefore, to eliminate this problem, measure only the interaction terms of the share of a firm's employees using a computer, either desktop or laptop, without the LAN connection (the variable COMPUTER) and the organizational factors. This means that we cannot analyse the impacts of mere mobility combined with the use of various organizational practices, but instead our analysis limits to the role of *connected mobility*.

[10] Prior to the estimations of the econometric models of which results are reported, we first estimated the OLS models and used the standardized residuals to eliminate outliers. Observations with the standardized residuals over three standards deviations away from the mean were dismissed in the final estimations. As a consequence, five observations were omitted from the estimation of the sales revenue growth equation and two from that of the profitability equation.

Table 2. The estimation results of the OLS model for the sales growth and profitability (Model 1 without interaction terms)

	SALES GROWTH	**PROFITABILITY**
Variable name	**Mean** **standard dev**	**Mean** **standard dev**
DESKTOP	0.01 0.08	0.01 0.05
LAPTOP	-0.07 0.06	-0.03 0.03
DESKTOP+LAN	1.47 1.27	0.35 0.68
LAPTOP+LAN	0.14 0.18	-0.07 0.07
WORK_REORG	0.02 0.06	0.03 0.03
OUTSOURCE	-0.02 0.02	0.00 0.02
EMPL_PARTICIP_FREQ	0.01 0.01	0.00 0.00
JOB_ROTATION	0.00 0.04	-0.03 0.02
PERFORM_PAY	0.10** 0.04	0.06** 0.02
OPTION_SCHEME	-0.04 0.06	-0.01 0.03
STOCK_OWNED_EMPL	-0.01 0.03	0.02 0.02
QUALITY	-0.03 0.03	-0.01 0.02
MONITOR	0.12*** 0.04	-0.01 0.02
MONITOR_PERFORM_PAY	-0.12** 0.05	-0.01 0.03
RD	0.14** 0.06	0.06** 0.03
AGE	0.01 0.01	-0.01 0.01
EMPL_50-99	0.10 0.07	-0.03 0.04
EMPL_100-199	-0.01 0.09	-0.07 0.05
EMPL_200-499	-0.13 0.12	-0.11* 0.07
EMPL_500-999	-0.22 0.17	-0.19 0.10
EMPL_OVER1000	-0.27 0.22	-0.21* 0.13
FAMILY_OWN	0.02 0.02	0.03* 0.02
+Industry dummies		
Constant	-0.80 -0.25	-0.11 0.14
Number of observations	292	297
R-square	0.2	0.22

NOTES: The OLS regressions robust to heteroscedasticity. Standard deviations in parentheses. *=.1 significance, **=.05 significance, ***=.01 significance.

The coefficients of the separate ICT use variables are not strongly related to the performance measures. We find that of the separate organizational practice variables the use of performance based wage scheme (the variable PERFORM_PAY) contributes clearly to profitability. This empirical finding interestingly complements the previous studies observing that performance based wages relate positively to productivity (Takao et al., 2008) and innovation (Koski et al., 2008). Our data also provide evidence on higher profitability of those firms of which managers and/or employees own the firm's stocks.

The estimation results of Model 2 further suggest that the variable capturing an interaction with the share of a firm's employees using Internet-connected laptops and the use of performance based wages combined with monitoring the firm's performance relates clearly positively to the firm's sales revenue growth. One possible explanation for this finding is that performance-based wages give an incentive for the firm's employees to work harder also off-site utilizing mobile, Internet-connected IT.

The estimation results further hint that the economic incentive systems may not work well or generate firm-level growth or improve profitability of the firms that have a higher share of employees using a computer without the Internet connection. The interaction term of the variables PERFORM_PAY and COMPUTER relates negatively and statistically significantly to the firm's sales revenue growth reflecting the importance of connectivity. In other words, firms with a relatively large non-mobile, non Internet-connected IT stock employing performance based wages face a substantially lower growth rates than others. This empirical finding hints that certain potentially powerful economic incentive systems may not be sufficient to produce better performance when the employees are using outdated IT stock without mobility and connectivity.

When the interactions between the ICT use and organizational practices are controlled for, outsourcing as such seems to relate negatively to the firm's growth. However, the estimated coefficient of the variable DESKTOP+LAN*OUTSOURCE is positive and statistically significant in both the sales growth and profitability equations. This implies that those firms

with a higher share of employees using a desktop with a LAN connection have benefited most from outsourcing.

Table 3: The estimation results of the OLS model for the sales growth and profitability (Model 2 with interaction terms)

	SALES GROWTH	**PROFITABILITY**
Variable name	**Mean** **standard dev**	**Mean** **standard dev**
DESKTOP	-0.01 0.41	0.46 0.30
LAPTOP	-0.18 0.20	0.05 0.13
DESKTOP_LAN	2.93 1.90	0.88 0.90
PORTABLE_LAN	0.21 0.70	-0.12 0.36
WORK_REORG	0.20* 0.12	0.08 0.06
OUTSOURCE	-0.14** 0.06	-0.05 0.03
EMPL_PARTICIP_FREQ	0.00 0.01	-0.01 0.01
JOB_ROTATION	0.01 0.09	0.00 0.05
PERFORM_PAY	0.09 0.11	0.10** 0.05
OPTION_SCHEME	-0.04 0.09	-0.02 0.06
STOCK_OWNED_EMPL	-0.04 0.05	0.06** 0.03
QUALITY	-0.07 0.08	-0.01 0.04
MONITOR	0.20* 0.11	0.04 0.05
MONITOR_PERFORM_PAY	-0.19 0.12	0.00 0.06
WORK_REORG*COMPUTER	-37.07 32.12	-22.44 17.50
OUTSOURCE*COMPUTER	0.16 0.15	0.04 0.08
EMPL_PARTICIP_FREQ*COMPUTER	-0.01 0.05	0.04 0.03
JOB_ROTATION*COMPUTER	0.06 0.29	-0.17 0.17
PERFORM_PAY*COMPUTER	-0.55** 0.28	-0.04 0.16
OPTION_SCHEME*COMPUTER	0.15 0.26	0.20 0.17
STOCK_OWNED_EMPL*COMPUTER	0.35*** 0.13	-0.11 0.08
QUALITY*COMPUTER	0.31 0.34	-0.07 0.21
MONITOR*COMPUTER	-0.28 0.36	-0.27 0.17
MONITOR_PERFORM_PAY*COMPUTER	0.30 0.41	-0.10 0.18
WORK_REORG*LAPTOP+LAN	13.98 83.17	150.09*** 38.85

OUTSOURCE*LAPTOP+LAN	0.02 0.28	0.05 0.16
EMPL_PARTICIP_FREQ* LAPTOP+LAN	0.02 0.08	0.02 0.03
JOB_ROTATION*LAPTOP+LAN	-0.69*** 0.26	-0.46** 0.23
PERFORM_PAY*LAPTOP+LAN	-0.02 0.41	0.10 0.27
OPTION_SCHEME*LAPTOP+LAN	-0.17 0.55	-0.36 0.35
STOCK_OWNED_EMPL*LAPTOP+LAN	0.12 0.26	-0.31* 0.16
QUALITY*LAPTOP+LAN	0.01 0.39	-0.34 0.28
MONITOR*LAPTOP+LAN	-0.50 0.35	0.28 0.19
MONITOR_PERFORM_PAY*LAPTOP+LAN	1.16*** 0.41	0.05 0.26
WORK_REORG*DESKTOP+LAN	-0.32 0.26	-0.40*** 0.13
OUTSOURCE*DESKTOP+LAN	0.25** 0.11	0.13** 0.06
EMPL_PARTICIP_FREQ*DESKTOP+LAN	0.01 0.03	0.01 0.02
JOB_ROTATION*DESKTOP+LAN	0.10 0.13	0.01 0.09
PERFORM_PAY*DESKTOP+LAN	0.08 0.17	-0.09 0.10
OPTION_SCHEME*DESKTOP+LAN	0.06 0.19	0.12 0.15
STOCK_OWNED_EMPL*DESKTOP+LAN	-0.05 0.12	-0.03 0.07
QUALITY*DESKTOP+LAN	0.06 0.16	0.06 0.08
MONITOR*DESKTOP+LAN	-0.03 0.17	-0.11 0.11
MONITOR_PERFORM_PAY*DESKTOP+LAN	-0.14 0.18	-0.02 0.12
RD	0.17*** 0.06	0.07** 0.03
AGE	0.00 0.02	-0.01 0.01
EMPL_50-99	0.08 0.07	-0.03 0.04
EMPL_100-199	-0.05 0.09	-0.07 0.05
EMPL_200-499	-0.19 0.13	-0.11 0.07
EMPL_500-999	-0.25 0.17	-0.20** 0.10
EMPL_OVER1000	-0.36 0.23	-0.25* 0.13
FAMILY_OWN	-0.36 0.23	0.02 0.02
+ Industry dummies		
Constant	-0.88 0.28	-0.20 0.14
Number of observations	297	292
R-square	0.36	0.31

NOTES: The OLS regressions robust to heteroscedasticity. Standard deviations in parentheses. *=.1 significance, **=.05 significance, ***=.01 significance.

A rather interesting is the finding that the order of magnitude of re-organization of tasks within a firm does not relate, as such, statistically significant to the firm's performance. The estimated coefficient of the interaction variable LAPTOP+LAN*RE_ORG is positive and statistically significant in the profitability equation. The coefficient of the variable DESKTOP+LAN*RE_ORG is, instead, negative and statistically significant. These findings suggest that a firm's benefits from the re-organization of work tend to be highest when combined with investments in and use of the mobile, Internet-connected IT devices. Instead, firms that have both a relatively high share of desktop users with a LAN connection and have also undertaken a major re-organization of work tasks, seem to be less profitable than others.

The estimated coefficient of the variable RD is positive and statistically significant in all of the estimated equations suggesting that innovation activities and firm performance are positively related.

4. Summary

This study uses a unique survey data from 398 Finnish manufacturing firms to explore how the order of magnitude of mobility and connectivity of a firm's ICT stock in conjunction with various organizational innovation and HRM practices affect the firm's performance. The empirical analysis provides a strong support for the importance of connected mobility in the modern business environment. The realization of potential benefits that a firm may acquire from the implementation of organizational changes, outsourcing strategies and the adoption of economic incentive systems depends substantially on the qualities of the ICT stock adopted by the firm. Specifically, the reported empirical findings suggest – providing support for our agency theory based argument - that a greater mobility associated with the use of the pertinent economic incentive scheme and a systematic performance monitoring promotes the firm's growth. It

seems that, instead, when a firm employs a potentially powerful economic incentive system in conjunction with the obsolete ICT stock, it impedes the firm's growth.

The data provide evidence on the contribution of re-organization of work to the firm's growth but mere work re-organization does not seem to contribute to the firm's profitability. Instead, re-organization of tasks within an organization is implemented most successfully, boosting profitability, when the firm's re-organization strategy incorporates the adoption of mobile, Internet-connected IT stock. It seems possible that a change towards more flexible work practices involving possibly more off-site work has provided substantial gains to the relatively early adopters of organizational innovations and ICT devices providing both the benefits of mobility and connectivity.

Our empirical findings stress the importance of connected mobility but we also find some evidence that a higher share of Internet-connected desktops may provide relative performance advantages for manufacturing firms in certain conditions. In 2005, computer use was already in a relatively mature state: all sample companies had at least 10 percent of their employees using a computer, and in 75 percent of the firms, all employees with a computer access had also a LAN connection. Thus, it is not surprising that the order of magnitude of desktop use as such does not explain (statistically significantly) variation in the firms' performance. However, we found that the firms with a relatively large non-mobile but Internet-connected IT stock outsourcing their activities in the recent past acquired both higher growth rates and profitability than others. This empirical finding hint that the Internet connected IT is a powerful means to reduce transactions costs particularly when part of the production takes place outside the firm's boundaries. Outsourcing generally provides for a firm means to react faster to changes in its market environment but, unfortunately, we have no data from the type of outsourcing to shed more light on the underlying benefits related to the outsourcing practices of the relatively more Internet-connected firms. We can only conclude that it seems that more connectivity complements

– possibly largely via the reduction of substantial transaction costs of outsourcing – a successful, growth promoting outsourcing strategy.

References

Black, S.E. and Lynch, L. (2004). What's driving the new economy: The benefits of workplace innovation. *The Economic Journal* 114, F97-F116.

Bloom, N. and van Reenen, J.V. (2007). Measuring and explaining management practices across firms and nations. *Quarterly Journal of Economics* 122, 1351-1408.

Bresnahan, T., Brynjolfsson, E. and Hitt, L. (2000). IT, workplace organization and demand for skilled labor: A firm-level analysis. Mimeo, MIT, Stanford, and Wharton.

Brynjolfsson, E. and Hitt, L.M. (1998). Information technology and organizational design: Evidence from micro data. Mimeo.

Brynjolfsson, and Hitt, (2000). Beyond computation: Information technology, organisational transformation and business performance. *Journal of Economic Perspectives* 14, 23-48.

Conyon, M.J. and Freeman, R.B. (2004). Shared modes of compensation and firm performance: UK evidence. in R. Blundell, D. Card and R. Freeman (eds), *Seeking a Premiere League Economy*, Chicago, University of Chicago Press, 109-146.

Gera, S. and Gu, W. (2004). The effects of organizational innovation and information technology on firm performance. *Productivity Monitor* 9, 37-51.

Gilley, K. and Rasheed, A. (2000). Making more by doing less: an analysis of outsourcing and its effects on firm performance. *Journal of Management*, 26, 763-790.

Giuri, P., Torrisi, S. and Zinovyeva, N. (2006). ICT, skills, and organisational change: Evidence from a panel of Italian Manufacturing firms. Laboratory of Economics and Management (LEM), Sant'Anna School of Advanced Studies, Pisa, Italy.

Grossman, S.J. and Hart, O.D. (1986). The costs and benefits of ownership: A theory of vertical and lateral integration. *Journal of Political Economy* 94, 691-719.

Ichniowski, C., Shaw, K. and Prennushi, G .(1997). The effects of human resources management practices on productivity: A study of steel finishing lines. *American Economic Review* 87, 291-313-

Jones, D.C., Katao, T., and Mäkinen, M. (2008). *The effects of human resource management practices on firm performance – preliminary evidence from Finland*. Helsinki, ETLA Discussion paper No. 1121.

Koellinger, P. (2008). The relationship between technology, innovation, and firm performance: Empirical evidence on e-business in Europe. *Research Policy* 37, 1317-28.

Koski, H., Marengo, L. and Mäkinen, I. (2008). Managerial practices, performance and innovativeness: Some evidence from Finnish manufacturing. *Etla Discussion Paper* No. 1176.

Maliranta, M. and Rouvinen, P. (2004). Informational mobility and productivity – Finnish evidence. *Economics of Innovation and New Technology* 15, 605-616.

Maury, B.(2006). Family ownership and firm performance: Empirical evidence from Western European corporations. *Journal of Corporate Finance* 12, 321-341.

Murphy, M. (2002). Organisational change and firm performance. *OECD Science, Technology and Industry Working Papers*, 2002/14, Paris.

Rawley, E. (2006). How do mobile information technology networks affect firm strategy and performance? Firm-level evidence from taxicab fleets. NET Institute. Working Paper No 06-28.

White, H. (1980). A heteroscedasticity-consistent covariance matrix estimator and a direct test for heteroscedasticity. *Econometrica* 48, 817-838.