PAPERS PRESENTED AT THE
SALTSJÖBADEN CONFERENCE OCTOBER 2010

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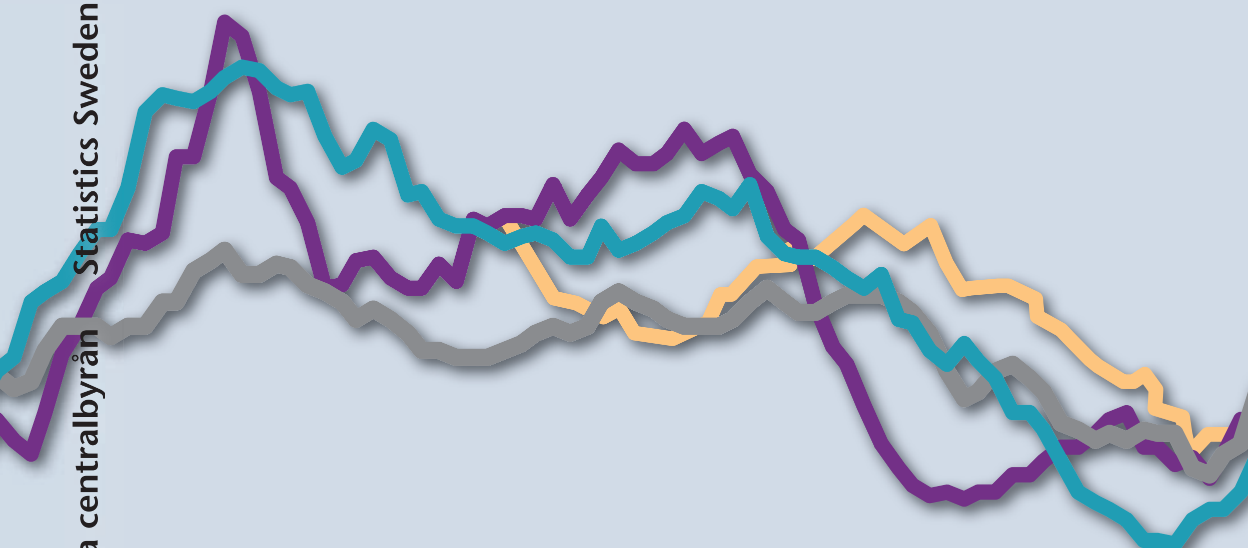

Yearbook on Productivity 2010

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Foreword

Growth is important. Today's growth is what we have to live on tomorrow. This is why we have focused on productivity and growth, and this is why Statistics Sweden has decided to create a yearbook on productivity. The yearbook is also an important part of our work on improving the economic statistics in Sweden. The objectives and priorities for this work were outlined by the Commission on the Review of Economic Statistics. The commission's proposals were well received by the Government, which commissioned Statistics Sweden to carry out this programme, of which this yearbook is a part of. The results of this program was presented at this year's conference.

This yearbook contains a number of productivity studies. The articles have been written by colleagues outside Statistics Sweden as well as people from our own organisation or in cooperation. This year's yearbook is the sixth one and was presented at our yearly conference in Saltsjöbaden as the coming yearbook.

We want to especially thank Paul Schreyer, Elif Köksal-Oudot, Vincenzo Spiezia and Graham Vickery at the OECD and Michel Polder at Statistics Netherlands. Our own contribution this time consists of a part of our Flex-3 project which has been done in cooperation with Annette Nylund and Hanna Wallén at the Royal Institute of Technology, Markus Lagerquist and Marina Aksberg at Stockholm University which we are much in debt to. Those involved in this yearbook at Statistics Sweden include: Olle Grünewald, Caroline Ahlstrand, Lana Omanovic and Hans-Olof Hagén, Project Manager.

Statistics Sweden, December 2010

Stefan Lundgren
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Are ICT Users More Innovative? An analysis of ICT-enabled Innovation in OECD Firms

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Abstract

The aim of this study is to assess the effects of information and communications technologies (ICTs) on the firms' capabilities to innovate in a selection of OECD countries. Our findings support the hypothesis that ICTs act an enabler of innovation, particularly for product and marketing innovation, in both manufacturing and services. However, we did not find any evidence that ICT use increases the capability of a firm to cooperate, to develop innovation in-house or to introduce products new-to-the-market. These results suggest that ICTs enable firms to adopt innovation but they not increase their "inventive" capabilities.

Introduction

The aim of this study is to assess the effects of information and communications technologies (ICTs) as an enabler of innovation in a selection of OECD countries. Innovation refers to product, process, organisational and marketing innovations (see OECD/Eurostat, Oslo Manual, 2005).

ICTs have the potential to increase innovation by speeding up the diffusion of information, favouring networking among firms, enabling closer links between businesses and customers, reducing geographic limitations, and increasing efficiency in communication.

Previous analysis confirms that ICTs play an important role in enabling business innovation, *e.g.* Brynjolfsson and Hitt, 2000; Gago and Rubalcaba, 2007; Crespi *et al.*, 2007; Eurostat, 2008; Van Leeuwen, 2008; Polder *et al.*, 2009. These studies, however, differ as regards their methodology and country coverage or they do not focus on the link between ICT use and innovation.

The main contribution of the present study is to address the effects of ICT use on innovation in a cross-country perspective based on a comparable data set and according to a common methodology.

The project is based on two statistical sources: the ICT Business Survey and the Innovation Survey. Information from these two surveys has been linked at the firm level. Due to confidentiality reasons, the analysis for this paper has been carried out by a network of national researchers with access to the micro-data, based on the same econometric model set by the OECD.

The network consisted of 14 researchers[1] from 9 countries: Canada, Italy, Luxembourg, the Netherlands, Norway, Spain, Sweden, Switzerland and the United Kingdom.

We adopted a simple approach, which is to test whether the expected effects of ICT use on innovation are supported by the data. The research, therefore, consists of a set of 19 testable hypotheses about the effects of ICT use on innovation, grouped under 3 themes:

- Innovation capabilities;
- Innovation trajectories;
- Cooperation in innovation.

As innovation is considered a key determinant of business productivity, the findings of this study would be relevant for businesses and policy makers alike.

The study is organized as follows. Section 1 summarizes the main findings by previous studies. Section 2 introduces the definitions of innovation and ICT use. Section 3 presents the dataset used in this study while Sections 4 and 5 discuss the research questions and the methodology, respectively. The main findings are discussed in Section 6. Finally, Section 7 draws the main conclusions and makes suggestions for further work.

[1.] Sylvain Ouellet (Canada), Valeria Mastrostefano and Alessandra Nurra (Italy), Leila Ben-Aoun and Anne Dubrocard (Luxembourg), Thomas Kooten and George Van Leeuwen (Netherlands), Marina Rybalka (Norway), Olga Ureña Fernandez and Maria Martinez (Spain), Hans-Olof Hagén (Sweden), Martin Woerter (Switzerland), Peter Stam and Mark Franklyn (United Kingdom). The project benefitted from comments by Andrea Panizza and Marc Bogdanowicz (EC-IPTS, Seville).

1 Previous findings

Business innovation is regarded as a key determinant of both individual business success and national economic growth. At the micro level, business innovation has the potential to increase consumer demand through improved product or service quality and simultaneously decrease production costs. More importantly, strong business innovation at a macro level increases multifactor productivity thus lifting international competitiveness, economic growth and real per capital incomes. Therefore, it is of great interest to businesses and policy makers alike, to identify those factors which stimulate innovation and to understand how these factors interact.

ICT is a valuable source of business innovation because it provides substantial efficiency gains. As Koellinger (2005) puts it “ICT makes it possible to reduce transaction costs, improve business processes, facilitate coordination with suppliers, fragment processes along the value chain (both horizontally and vertically) and across different geographical locations, and increase diversification.”

Each of these efficiency gains provides an opportunity for innovation. For example, IT automated system links lead to more streamlined businesses processes and allow staff to be more responsive to emerging customer needs. Similarly, technologies which allow staff to effectively communicate and collaborate across wider geographic areas will encourage strategies for less centralized management, and more flexible external relations, all of which involve different types of innovative activity.

Gretton, Gali and Parham (2004) have suggested two additional reasons why business use of ICT encourages innovative activity. Firstly, ICT is a 'general purpose technology' which provides an 'indispensable platform' upon which further productivity-enhancing changes, such as product and process innovations, can be based. For example, a business which establishes a web presence sets the groundwork from which process innovations, such as electronic ordering and delivery, can be easily developed. In this way, adopting general purpose ICT makes it relatively easier and cheaper for businesses to develop innovations.

Secondly, the spillover effects from ICT usage, such as network economies, can be sources of productivity gains. For example, staff in businesses which have adopted broadband Internet are able to collaborate with wider networks of academics and international researchers more closely on the development of innovations and keep abreast of current consumer trends. These are spillover benefits because the R&D efforts of other researchers in the collaborative group can be appropriated by all.

Information and communication technologies can also be seen as a source of innovation because they enable closer links between businesses, their suppliers, customers and competitors and collaborative partners. These agents are all understood to be important sources of ideas for innovation. By enabling closer communication and collaboration, ICT assists businesses to be more responsive to innovation opportunities and provides significant efficiency gains. For example, having ICTs such as broadband Internet, web presence and automated system linkages, assists businesses to keep up with customer trends, monitor competitor's actions and get rapid user feedback, thereby assisting them to exploit opportunities for all types of innovations.

Previous econometric analysis confirms that ICTs play an important role in enabling business innovation. Gago and Rubalcaba (2007) find that businesses which invest in ICT, particularly those which regard their investment as very important, or strategically important, are significantly more likely to engage in services innovation.

The Eurostat ICT impacts project (Eurostat, 2008) reveals that – on average – ICT usage is positively related to firm performance. The strength of these results varies over countries, however, and it also appears that the benefits of different types of ICT usage are industry specific. Van Leeuwen (2008) shows that e-sales and broadband use affect productivity significantly through their effect on innovation output. Broadband use, however, only has a direct effect on productivity if R&D is not considered as an input to innovation.

This approach is further developed by Polder *et al.* (2009). Their study finds out that ICT investment is important for all types of innovation in services, while it plays a limited role in manufacturing, being only marginally significant for organisational innovation.

Another line of literature motivates the importance of ICT for organisational innovation (see Brynjolfsson and Hitt, 2000 for a survey). Case studies reveal that the introduction of information technology is combined with a transformation of the firm, investment in intangible assets, and of the relation with suppliers and customers. Electronic procurement, for instance, increases the control of inventories and decreases the costs of coordinating with suppliers, and ICT offers the possibility for flexible production: just-in-time inventory management, integration of sales with production planning, et cetera. A lack of proper control for intangible assets is seen as a possible candidate for explaining the differences in productivity growth that are observed between Europe and the US.

The available econometric evidence at firm level shows that a combination of investment in ICTs and changes in organisations and work practices facilitated by these technologies contributes to firms' productivity growth. Crespi *et al.* (2007) use CIS data for the UK and find a positive effect on firm performance of the interaction between IT and organizational innovation. They also find a significant effect of competition on organisational innovation.

These results confirm recent findings that ICTs are an important enabler of capturing and processing knowledge in the innovation throughput stage. In addition, the observed industry differences suggest that new ICT applications, such as broadband connectivity and e-commerce, are more important in services than in manufacturing.

2 Definitions

Innovation

The Oslo Manual defines an 'innovation' as (OECD/Eurostat 2005, p. 46):

"...the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organisation or external relations."

A product innovation is the introduction of a good or service that is significantly improved with respect to its characteristics or intended uses and includes significant improvements in technical specifications, components and materials, incorporated software and user friendliness or other functional characteristics (Oslo Manual 2005, p. 48). Design changes which do not involve a significant change in the product's functional characteristics or intended use, such as a new flavour or colour option, are not product innovations. Product innovations in services can include significant improvements in how the product is provided, such as home pick-up or delivery services, or other features which improve efficiency or speed.

A process innovation is a new or significantly improved production or delivery method, including significant changes in techniques, equipment and/or software (Oslo Manual 2005, p. 49). For example, introduction of a new automation method on a production line, or in the context of ICT, developing electronic system linkages to streamline production and delivery processes, are both process innovations. With respect to services, it is often difficult to distinguish a product and process innovation. The Oslo Manual (2005, p. 53) contains the following guidelines to distinguish the two types of innovation:

if the innovation involves new or significantly improved characteristics of the service offered to customers, it is a product innovation;

if the innovation involves new or significantly improved methods, equipment and/ or skills used to perform the service, it is a process innovation.

An organisational or managerial innovation is the implementation of a new or significantly improved method of the firm's business practices, workplace organisation or external relations. It requires more than mere organisational change or restructure. In fact, the organisational method must not have been previously used by the business and must be the results of strategic decisions taken by management (Oslo Manual 2005, p. 49). Examples include implementation a new method for distributing responsibilities and decision making among employees, decentralising group activity, developing formal or informal work teams, new types of external collaboration with research organisations or the use of outsourcing or sub-contracting for the first time (Oslo Manual 2005, p. 52).

A marketing innovation is the implementation of a new or significantly improved marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing. The marketing method must not have been previously used by the firm and must be part of a new marketing concept or strategy representing a significant departure from the firm's existing methods (Oslo Manual 2005, p. 50).

The OECD has recommended that countries collect qualitative, survey data on innovation activities. These qualitative measures of innovation are more encompassing than traditional innovation measures. For example, measures such as R&D expenditure per employee, patents received or sales derived from new products will not encompass all the innovative efforts of a business and will be biased towards particular types of innovation.

ICT use

The definition of ICT use by firm is less clear-cut and codified. Computer use does not seem a relevant criterion any longer, as virtually all firms use the computer. The use of a computer network seems to be a more appropriate measure of ICT use, although the information technology in use (*e.g*. Extranet, WAN, etc) may have different effects on innovation.

Given the dominance of IP-based networks, one may reasonably argue that Internet use, particularly broadband Internet, is what makes a firm an IC user. Some previous studies (Eurostat, 2008) have pointed out that the percentage of broadband connected employees is a better measure of the intensity of ICT use by firms.

As there is no unique measure of the intensity of ICT use, we explored the correlation between the probability to innovate and a set of potential indicators for ICT use available from the ICT Business Surveys: the number of web facilities; the number of automatic IT links; the share of employees with a broadband connection to the Internet; the value of e-sale; the value of e-purchasing; the presence of a firm's web page; the first factor from a factor analysis of all the above indicators; the simple average of the above indicators.

The number of web facilities and the number of automatic IT links turned out to have the highest correlation to innovation in all countries. Therefore, our econometric analysis included either one of these two variables as a measure of the intensity of ICT use.

The number of web facilities is computed from the answers to the following questions ("Eurostat model for a Community Survey on ICT Usage and e-Commerce in Enterprises 2006"):

B9.	**Did the Web Site of your enterprise provide the following facilities, during January 2006?**		
	(your enterprise <u>as provider</u> of Internet services)	Yes	No
	a) Marketing the enterprise's products	☐	☐
	b) Facilitating access to product catalogues and price lists	☐	☐
	c) Providing after sales support	☐	☐

Firms are asked to answer all questions with yes or not. Therefore, the indicator varies between 0 (firms has no web facilities) to 3 (firms has all web facilities).

The number of automatic IT links is based on the answers to the following questions from the same survey:

A9*.	**Did your enterprise's IT systems for managing orders link automatically with any of the following IT systems, during January 2006?**		
		Yes	No
	a) Internal system for re-ordering replacement supplies	☐	☐
	b) Invoicing and payment systems	☐	☐
	c) Your system for managing production, logistics or service operations	☐	☐
	d) Your suppliers' business systems (for suppliers outside your enterprise group)	☐	☐
	e)Your customers' business systems (for customers outside your enterprise group)	☐	☐

Firms are asked to answer all questions with yes or not. Therefore, the indicator varies between 0 (firms has no automatic IT link) to 5 (firms has all automatic IT links).

Strictly speaking, none of these two indicators is a measure of the intensity of ICT use by firms. They are rather a measure of the sophistication or scope of ICT use. However, both indicators are correlated to the intensity of use. Adding a new a new web facility or a new automatic link to the firm's IT system is costly and a firm would not do undertake such an investment if it did not use it.

Clearly, firms with the same automatic IT links or web facilities may use them differently and our indicators would not capture these differences. In addition, IT links and web facilities seem biased towards the use of ICTs for e-commerce and e-business but they may be a poorer proxy for other ICT-enabled activities relevant for innovation, eg: communication.

Bearing these limitations in mind, in the rest of this study we will regard the number of web facilities and of automatic IT links as a measure of the intensity of ICT use by firms.

3 The dataset

The project relies on two statistical sources: 1. the ICT Business Survey; and 2. the Innovation Survey.

The ICT Business Survey follows the OECD Model Survey in virtually all OECD countries. Therefore, comparable statistics on ICT use in firms are easily available in all countries.

Innovation surveys, on the contrary, tend to be more country-specific. The Community Innovation Survey (CIS) is a noticeable exception, as the same questionnaire is submitted to firms in all EU countries participating in the survey. In general, however, the definitions of innovation comply with the recommendations of the OSLO manual (OECD, 2005). This is the case for two non-EU countries included in this study: Canada and Switzerland.

The analysis of the ICT effects of innovation requires "linking" the ICT survey and the Innovation survey at the level of firm. Therefore, the sample for the analysis is limited to those firms that responded to both the ICT survey and the Innovation survey.

Table 1 shows the number and percentage of firms in the innovation survey that also responded to the ICT survey in the countries considered in the present study.

Table 1
Number of firms included in both ICT and Innovation surveys – latest year available (as a % of all firms in the Innovation Survey)

Country		Manufacturing	Services	Total	Number	Notes
Canada	2007	7%	-	7%	488	Imperfect match between ICT and Innovation surveys
Italy	2004	33%	25%	29%	4391	
Ireland	2005	47%	16%	30%	584	
Luxembourg	2007	51%	49%	49%	369	
Netherlands	2007	61%	60%	61%	3549	
Norway	2006	34%	33%	33%	1421	
Portugal	2005	16%	24%	20%	1476	
Sweden	2006	14%	20%	17%	561	
Switzerland	2008	100%	100%	100%	2555	
UK	2006	10%	19%	13%	706	

Table 1 shows that:
In most countries, only a small percentage firms in the Innovation survey responded also to the ICT survey. This percentage is particularly low for services. This raises an issue of representativeness of the joint ICT-Innovation sample, which is likely to be biased towards manufacturing industries and large firms.

In many countries, the total number of firms in the joint ICT-Innovation sample is relatively small. This implies that the number of variables that we can consider in an econometric analysis is fairly limited.

The above limitations result from the survey design currently in place for most surveys in a large majority of countries. Traditionally, surveys have been designed to estimate representative "averages" for the population and for selected groups of the population. In order to reduce the burden on the respondents, samples for different surveys have been designed as to reduce overlapping or even to exclude it (eg: the ICT survey and the CIS in France).

As the capability to analyse micro data increases, largely due to ICT, the survey design has to be reconsidered in order to facilitate data linking between different surveys *and/or* to merge questions from different survey – eg: ICT and Innovation surveys – into the same one. Both strategies have significant implications in terms of costs for the Statistical Offices and burden for the respondents. Therefore, an assessment by the NSOs on how to meet the demand for micro data is becoming increasingly necessary.

The present analysis is based on data on manufacturing and services in all countries except Canada, where the matching between the ICT and Innovation surveys was possible only for firms in manufacturing due to the different statistical units used in the two surveys (firms for the ICT and establishment in the Innovation survey).

4. Research questions

The aim of this research project is to assess the effects of ICTs as an enabler of innovation.

ICT has the potential to increase innovation by speeding up the diffusion of information, favouring networking among firms, reducing geographic limitations, and increasing efficiency in communication.

These effects can be analysed by looking at whether the use of ICT in firms is associated to:

Box 1. List of testable hypotheses by theme

1. Innovation capabilities

Hypothesis 1: The probability to innovate increases with the intensity of ICT use.
Hypothesis 1a: The probability to introduce a new product increases with the intensity of ICT use.
Hypothesis 1a1: The probability to introduce a new good increases with the intensity of ICT use.
Hypothesis 1a2: The probability to introduce a new service increases with the intensity of ICT use.
Hypothesis 1b: The probability to introduce a new process increases with the intensity of ICT use.
Hypothesis 1c: The probability to introduce a new organisational model increases with the intensity of ICT use.
Hypothesis 1d: The probability to introduce a new marketing methods increases with the intensity of ICT use.

2. Innovation trajectories

Hypothesis 2: Among all firms introducing a new product, the probability to introduce a product new-to-the-market (as opposed to new-to–the-firm) increases with the intensity of ICT use.
Hypothesis 3: Among all firms introducing a new product, the probability to introduce a new product developed in-house or in cooperation with other firms (as opposed to "developed by other firms") increases with the intensity of ICT use.
Hypothesis 4: Among all firms introducing a new process, the probability to introduce a new process developed in-house or in cooperation with other firms (as opposed to "developed by other firms") increases with the intensity of ICT use.
Hypothesis 5a: Among all innovative firms, the probability to innovate in organisation OR marketing increases with the intensity of ICT use.
Hypothesis 5b: Among all innovative firms, the probability to innovate in organisation AND marketing increases with the intensity of ICT use.
Hypothesis 5c: Among all innovative firms, the probability to innovate in organisation increases with the intensity of ICT use.
Hypothesis 5d: Among all innovative firms, the probability to innovate in marketing increases with the intensity of ICT use.
Hypothesis 6a: Among all innovative firms, the probability that product innovations are integrated to marketing innovations increases with the intensity of ICT use.
Hypothesis 6b: Among all innovative firms, the probability that process innovations are integrated to organisation innovations increases with the intensity of ICT use.

Hypothesis 6c: Among all innovative firms, the probability that product innovations were integrated to organisation OR marketing innovations increases with the intensity of ICT use.
Hypothesis 6d: Among all innovative firms, the probability that process innovations were integrated to organisation OR marketing innovations increases with the intensity of ICT use.

3. Cooperation in innovation
Hypothesis 7: Among all innovative firms, the probability to innovate in cooperation with other firms or institutions increases with the intensity of ICT use.

1) higher probability to innovate;
2) specific features of innovation; and
3) higher probability to cooperate in innovation.

We adopted a simple approach, which is to test whether the expected effects of ICT use on innovation are supported by the data. Therefore, the research consists of a set of 19 testable hypotheses about the effects of ICT use on innovation, grouped under 3 themes (see Box 1)

5 The model

The above hypotheses have been tested through a series of "probit equations with endogenous regressors" (Wooldridge, 2002; pp. 472-478). The probability to introduce an innovation with specific features (*e.g*. product, marketing, new-to-the-market, etc.) is modelled as a function of:

- the intensity of ICT use;
- whether the firm carried out R&D;
- the firm's size (number of employees); and
- the educational attainments of its employees (as a proxy of skills).

The model was estimated through a "two-stage conditional maximum likelihood" (Rivers and Vuong, 1988) with firm or industry random effects. In order to control for the endogeneity of the ICT variable, we used and Instrumental Variable (IV) approach. We tested a number of ICT variables which are expected to be correlated to ICT use but not to innovation. The variable e-government turned out to be a valid instrument in all countries except the Netherlands and Switzerland, where we used the lagged ICT variable as an IV.

In more formal terms, we started with the following model:

(1) $Inno_i^* = \beta_0 + \beta_1 \ln(size_i) + \beta_2 R\&D_i + \beta_3 skills_i + \sum_j \gamma_j D_{j,i} + u_i$

(2) $ICT_i = \delta_0 + \delta_1 \ln(size_i) + \delta_2 R\&D_i + \delta_3 skills_i + \delta_4 IV_i + v_i$

(3) $Inno_i = 1\ if\ Inno_i^* > 0;\ Inno_i = 0\ otherwise$

(4) $D_{j,i} = 1\ if\ \ ICT_i = j; D_{j,i} = 0\ otherwise$

where *i = 1, 2, …., N* indicates the firms; *j = 1, 2, … 5* the frequency of ICT use; *R&D* is equal to 1 if the firm carries out R&D, 0 otherwise; and (u_i, v_i) is assumed to have a zero mean, bivariate normal distribution and to be independent of all exogenous variables in (2).

If u_i and v_i are correlated, ICT is endogenous and the Probit estimates of all variables in (1) are biased. Under the assumption of joint normality of (u_i, v_i), we can write

(5) $u_i = \theta v_i + e_i$

where $e_i \sim N[0, Var(u_i) - Cov(u_i, v_i)]$.

Therefore, the above model can be rewritten as:

(6) $Inno_i^* = \beta_0 + \beta_1 \ln(size_i) + \beta_2 R\&D_i + \beta_3 skills_i + \sum_j \gamma_j D_{j,i} +$
$\theta \hat{v}_i + e_i$

where $\hat{v}_i$ are the OLS residuals[2] of equation (2).

Equation (6) can be estimated by Probit and the Average Partial Effects (APEs) computed as the average of the Partial Effects (PEs) across $\hat{v}_i$.

Three countries (the Netherlands, Norway and Sweden) estimated the model as a panel with firms' random effects and industry dummies; due to data limitations, the remaining six countries estimated a cross-section with industries' random effects[3].

[2] As ICT is a discrete variable, the OLS estimates of $\hat{v}_i$ are not consistent. Nonetheless, they lead to consistent estimates of equation (6) because they are orthogonal to all exogenous variables – see, for instance, Heckmann (1978).

[3] We did not test for fixed effects because this would lead to inconsistent estimates in the context of the "unobserved effects probit model" used in this study (Wooldridge, 2002, p. 484). This situation is known as the "incidental parameters problem".

The model can be interpreted as a simultaneous model, where the decision to innovate and to use ICTs is taken jointly. In this sense, the model does not predict that ICT use is the *cause* of innovation, rather that ICTs are an *enabler* of innovation: firms use ICTs as a tool or a "platform" for innovation.

6 Main findings

Table 2 and 3 show the findings of our analysis[4]. The intensity of ICT use was measured as the number of web facilities (0 to 3) in table 2 and as the number of automated IT links (0 to 5) in table 3. Both ICT use variables provide similar results, although the estimates based on the number of automated IT links are less stable. Therefore, in what follow, we will focus on the results based on the number of web facilities.

6.1 Innovation capabilities

- *ICT use increases the probability to innovate*

The number of web facilities increases the probability to innovate for the manufacturing firms in 4 countries out of 8. The increase is the highest in Spain and Italy, where firms with three web facilities are 81% and 66%, respectively, more likely to innovate than firms with no web facilities. In Canada and the United Kingdom the increase is 26% and 22%, respectively. Firms with two web facilities in Norway are 8% more likely to innovate, although the effect becomes not significant for a higher number of facilities.

The number of web facilities increases the probability to innovate for the service firms in 5 countries out of 7. The increase is the highest in Spain and Italy, where firms with three web facilities are over 60% more likely to innovate than firms with no web facilities. In Norway and the United Kingdom the increase is 27% and 26%, respectively. Firms with three web facilities in Switzerland are 7% more likely to innovate than firms with no web facilities.

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[4] The results were not significant for Sweden. This is probably due to the combination of two factors: a smaller number of observations; a lower variability in the ICT indicators due to the higher sophistication of ICT use by Swedish firms. An earlier study, based on the same dataset but using a different model, found out that ICT use increases both the probability to innovate and the innovation activities among the innovators
("ICT use, Broadband and Productivity in Sweden")
http://www.scb.se/statistik/_publikationer/OV9999_2008A01_BR_X76BR0802.pdf

- *ICT use increases the probability to introduce a new product both in manufacturing and services*

The number of web facilities increases the probability to introduce a new product for the manufacturing firms in 5 countries out of 8. The increase is the highest in the Netherlands, where firms with three web facilities are 81% more likely to innovate in product than firms with no web facilities. The increase is 31% both for Canada and Italy. In the United Kingdom and Spain the increase is 23% and 11%, respectively. Firms with two web facilities in Norway are 14% more likely to introduce a new product, although the effect becomes not significant for a higher number of facilities.

The effect of ICT on the probability to introduce a new product in manufacturing seems limited to new goods. In fact, the effect on the probability to introduce a new service is lower or not significant.

The number of web facilities increases the probability to introduce a new product for the service firms in 6 countries out of 7. The increase is the highest in the United Kingdom and Italy, where firms with three web facilities are 32% and 21% more likely to innovate in product than firms with no web facilities. In Norway, the Netherlands, and Switzerland, the increase is 14%, 13 and 12%, respectively, while it is 8% in Spain.

The effect of ICT use on the probability to introduce a new product in services mainly occurs through new services. The only exception is the Netherlands, where the effect of web facilities is higher on new goods (32%) than on new services (14%).

- *ICT use has a significant effect on the probability to introduce a process innovation*

A significant effect of web facilities on the probability to introduce a new production process in manufacturing was found only in Italy, the Netherlands and Switzerland. In these countries, firms with three web facilities are 35%, 12% and 7% more likely to innovate in process than firms with no web facilities.

As for services, a significant effect was found in Spain (37%), Italy (27%) and Norway (16%).

Table 2
Probability to innovate associate to the intensity of ICT use (number of web facilities) – Manufacturing

	Canada			Italy			Luxembourg			Netherlands		
Number of web facilities	1	2	3	1	2	3	1	2	3	1	2	3
Innovation capabilities												
1: Any innovation	13%	22%	26%	31%	50%	66%	71%	94%	87%	61%	95%	98%
1a: New product	19%	29%	31%	19%	30%	31%	9%	20%	17%	45%	70%	81%
1a1: New good	16%	27%	34%	19%	26%	29%	.	.	.	49%	69%	77%
1a2: New service	-43%	-59%	-52%	4%	12%	9%	.	.	.	5%	4%	5%
1b: New process	-1%	11%	5%	19%	26%	35%	-14%	-13%	-13%	3%	7%	12%
1c: New organisation	5%	10%	24%	19%	31%	43%	10%	40%	-1%	7%	13%	16%
1d: New marketing	7%	22%	29%	19%	23%	38%	7%	23%	4%	18%	26%	36%
Innovation trajectories												
2: New-to-the-mkt	7%	20%	12%	3%	11%	0%	26%	24%	-2%	3%	-3%	2%
3: Prod in-house/coop				2%	2%	4%	.	.	.	65%	95%	98%
4: Proc in-house/coop				0%	1%	3%	.	.	.	-8%	-3%	-8%
5a: Org OR mrktg	-3%	0%	14%	1%	3%	11%	.	.	.	4%	12%	16%
5b: Org AND mrktg	4%	17%	23%	9%	9%	20%	5%	31%	6%	13%	16%	28%
5c: Org	-4%	-4%	10%	-1%	3%	7%	-1%	18%	-3%	-1%	3%	10%
5d: Mrktg	6%	22%	27%	11%	10%	23%	6%	21%	2%	17%	26%	37%
6a: Prod AND mktg	13%	27%	27%	5%	9%	16%	0%	1%	0%	8%	14%	18%
6b: Proc AND org	-11%	-11%	-2%	6%	14%	15%	-20%	0%	-10%	2%	5%	7%
6c: Prod AND mktg/org	10%	15%	29%	3%	8%	11%	.	.	.	9%	14%	17%
6d: Proc AND mktg/org	-11%	-5%	-2%	6%	10%	15%	-22%	-7%	-20%	4%	6%	12%
Cooperation in innovation												
7: Coop				6%	3%	-1%	.	.	.	2%	6%	1%
Data	Cross-section			Cross-section			Cross-section			Panel		
Estimation	Random Effects			Random Effects			Random Effects			Random Effects		
N. obs	488			2479			128			675		

	Norway			Spain			Switzerland			United Kingdom		
Number of web facilities	1	2	3	1	2	3	1	2	3	1	2	3
Innovation capabilities												
1: Any innovation	5%	8%	7%	35%	68%	81%				.	14%	22%
1a: New product	3%	14%	10%	-3%	6%	11%				11%	15%	23%
1a1: New good	2%	9%	0%	-5%	4%	9%				.	15%	22%
1a2: New service	1%	3%	8%	-6%	2%	3%				7%	9%	8%
1b: New process	-1%	4%	-4%	28%	44%	54%		2%	7%	.	.	.
1c: New organisation	2%	6%	1%	3%	8%	13%				12%	13%	19%
1d: New marketing	7%	20%	18%	6%	7%	16%				.	.	18%
Innovation trajectories												
2: New-to-the-mkt	3%	5%	4%	12%	-5%	-5%		5%	10%	.	.	.
3: Prod in-house/coop	-1%	-2%	-2%	9%	-4%	5%						
4: Proc in-house/coop	4%	-3%	-1%	-14%	-2%	-1%				.	.	.
5a: Org OR mrktg	5%	13%	11%	6%	1%	7%				.	.	.
5b: Org AND mrktg	5%	15%	7%	3%	5%	13%				.	.	.
5c: Org	1%	6%	-2%	0%	-2%	1%				.	.	.
5d: Mrktg	8%	23%	20%	8%	7%	17%				.	.	15%
6a: Prod AND mktg	8%	20%	14%	5%	-1%	7%				.	.	23%
6b: Proc AND org	-41%	-57%	-73%	12%	3%	5%				.	.	.
6c: Prod AND mktg/org	3%	15%	8%	17%	1%	8%				-	14%	19%
6d: Proc AND mktg/org	0%	12%	1%	7%	3%	6%				30%	40%	39%
Cooperation in innovation												
7: Coop	0%	1%	-3%	-2%	-6%	-3%				.	16%	14%
Data	Panel			Cross-section			Panel			Cross-section		
Estimation	Random Effects			Random Effects			Random Effects			Random Effects		
N. obs	1697			2569			1888			632		

Bold: significant at 10%; Underlined: significant at 5%; Double-underlined: significant at 1%; ".": non significant; <<blank>>: not available

Table 2 (continued)
Probability to innovate associate to the intensity of ICT use (number of web facilities) - Services

	Italy			Luxembourg			Netherlands			Norway		
Number of web facilities	1	2	3	1	2	3	1	2	3	1	2	3
Innovation capabilities												
1: Any innovation	42%	60%	61%	-6%	-4%	5%	1%	3%	3%	14%	23%	27%
1a: New product	17%	22%	21%	3%	10%	24%	4%	14%	13%	4%	10%	14%
1a1: New good	10%	11%	10%	2%	8%	9%	29%	35%	32%	3%	6%	0%
1a2: New service	13%	18%	18%	3%	16%	24%	0%	10%	14%	2%	6%	14%
1b: New process	21%	22%	27%	-13%	-8%	-9%	-7%	-1%	-2%	7%	8%	16%
1c: New organisation	32%	49%	46%	-6%	-20%	-7%	0%	10%	5%	5%	9%	19%
1d: New marketing	7%	10%	14%	-4%	-4%	5%	12%	22%	38%	7%	16%	22%
Innovation trajectories												
2: New-to-the-mkt	-3%	5%	14%	17%	10%	10%	1%	16%	-2%	-10%	-19%	1%
3: Prod in-house/coop	5%	-8%	14%	-13%	-17%	-8%	6%	9%	1%	2%	5%	8%
4: Proc in-house/coop	4%	-6%	9%	.	.	.	-11%	0%	3%	1%	-3%	12%
5a: Org OR mrktg	-1%	5%	1%	0%	-23%	-10%	5%	14%	12%	2%	6%	8%
5b: Org AND mrktg	5%	9%	15%	-3%	-6%	5%	-8%	-1%	4%	-7%	-2%	12%
5c: Org	-4%	3%	-3%	1%	-29%	-15%	-5%	3%	-3%	-7%	-7%	4%
5d: Mrktg	7%	10%	18%	-3%	-2%	8%	12%	22%	40%	1%	10%	17%
6a: Prod AND mktg	8%	6%	5%	-37%	-57%	-60%	3%	8%	25%	-1%	7%	9%
6b: Proc AND org	4%	3%	5%	-8%	-9%	-11%	12%	11%	17%	-3%	-10%	3%
6c: Prod AND mktg/org	6%	4%	6%	0%	-2%	8%	-4%	9%	8%	3%	11%	13%
6d: Proc AND mktg/org	5%	5%	4%	-4%	-8%	-4%	13%	14%	22%	3%	2%	14%
Cooperation in innovation												
7: Coop	3%	4%	3%	-2%	-4%	0%	16%	17%	22%	-15%	-15%	-17%
Data	Cross-section			Cross-section			Panel			Panel		
Estimation	Random Effects			Random Effects			Random Effects			Random Effects		
N. obs	1912			210			600			1273		

	Spain			Switzerland			United Kingdom		
Number of web facilities	1	2	3	1	2	3	1	2	3
Innovation capabilities									
1: Any innovation	37%	47%	60%			7%	17%	18%	26%
1a: New product	6%	3%	8%			12%	21%	23%	32%
1a1: New good	10%	0%	3%			10%	.	.	.
1a2: New service	3%	3%	8%				21%	23%	32%
1b: New process	30%	30%	37%				.	.	.
1c: New organisation	10%	34%	42%				18%	16%	23%
1d: New marketing	10%	4%	10%				12%	17%	18%
Innovation trajectories									
2: New-to-the-mkt	71%	7%	13%				.	.	.
3: Prod in-house/coop	-18%	7%	1%				19%	19%	18%
4: Proc in-house/coop	15%	4%	8%				0%	0%	0%
5a: Org OR mrktg	-38%	3%	4%				12%	-	-
5b: Org AND mrktg	11%	-3%	5%				34%	44%	43%
5c: Org	-34%	1%	2%				.	.	.
5d: Mrktg	7%	0%	7%				-	19%	16%
6a: Prod AND mktg	18%	-5%	-3%				27%	27%	32%
6b: Proc AND org	-15%	4%	6%				.	.	.
6c: Prod AND mktg/org	21%	-1%	2%				29%	27%	38%
6d: Proc AND mktg/org	-15%	4%	7%				.	.	.
Cooperation in innovation									
7: Coop	-1%	3%	8%				.	.	.
Data	Cross-section			Panel			Cross-section		
Estimation	Random Effects			Random Effects			Random Effects		
N. obs	2201			1469			1069		

Bold: significant at 10%; Underlined: significant at 5%; Double-underlined: significant at 1%; ".": non significant; <<blank>>: not available

Table 3
Probability to innovate associate to the intensity of ICT use (number of IT links) - Manufacturing

	Canada		Italy					Luxembourg					Netherlands				
Number of IT links	1-2	3-5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Innovation capabilities																	
1: Any innovation	25%	14%	.	.	.	.	.	-1%	26%	28%	32%	27%	-8%	-3%	1%	-3%	1%
1a: New product	13%	-6%	17%	25%	26%	33%	45%	-1%	-4%	18%	-25%	14%	-12%	1%	6%	1%	4%
1a1: New good	14%	-2%	16%	22%	25%	30%	41%	.	.	.	.	.	-19%	-2%	7%	4%	6%
1a2: New service	1%	0%	7%	9%	6%	10%	21%	.	.	.	.	.	2%	5%	0%	2%	-1%
1b: New process	13%	7%	13%	26%	28%	33%	47%	-8%	9%	-10%	-1%	1%	-8%	-2%	-1%	0%	2%
1c: New organisation	27%	31%	.	.	.	.	.	0%	1%	43%	-8%	13%	-5%	-8%	0%	5%	10%
1d: New marketing	10%	3%	16%	25%	24%	33%	36%	-4%	6%	9%	7%	0%	-6%	-8%	-5%	8%	9%
Innovation trajectories																	
2: New-to-the-mkt	12%	-6%	3%	14%	1%	13%	12%	-14%	-28%	-9%	10%	-41%	0%	1%	0%	5%	2%
3: Prod in-house/coop			3%	0%	3%	1%	1%	.	.	.	.	.	1%	-2%	1%	5%	2%
4: Proc in-house/coop			1%	1%	2%	2%	0%	.	.	.	.	.	-5%	-1%	8%	15%	6%
5a: Org OR mrktg	7%	20%	-3%	2%	1%	3%	0%	.	.	.	.	.	-5%	-10%	-2%	11%	11%
5b: Org AND mrktg	11%	6%	6%	2%	2%	7%	2%	1%	8%	22%	14%	0%	-1%	-4%	-4%	6%	7%
5c: Org	14%	26%	-7%	0%	2%	0%	-2%	-5%	-32%	13%	-24%	-8%	-1%	-7%	-1%	7%	10%
5d: Mrktg	4%	1%	9%	5%	1%	10%	4%	-6%	-5%	0%	0%	-9%	-4%	-7%	-6%	9%	9%
6a: Prod AND mktg	-9%	-6%	10%	3%	3%	8%	4%	0%	0%	0%	1%	0%	-1%	-6%	-7%	7%	9%
6b: Proc AND org	-4%	7%	-1%	2%	2%	11%	8%	-41%	-29%	-22%	-33%	-25%	-2%	-1%	-3%	7%	7%
6c: Prod AND mktg/org	0%	4%	7%	1%	3%	6%	3%	.	.	.	.	.	-2%	-13%	1%	5%	10%
6d: Proc AND mktg/org	-7%	4%	5%	0%	-1%	9%	5%	-46%	-71%	-65%	-81%	-78%	-2%	-1%	-4%	9%	7%
Cooperation in innovation																	
7: Coop			-2%	-1%	-2%	-2%	2%	.	.	.	.	.	-8%	6%	4%	13%	20%
Data	Cross-section		Panel					Cross-section					Panel				
Estimation	Random Effects		Random Effects					Random effects					Random Effects				
N. obs	488		2479					134					278				

	Norway					Spain					United Kingdom				
Number of IT links	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Innovation capabilities															
1: Any innovation	2%	-1%	8%	2%	0%	58%	76%	83%	86%	90%	.	.	7%	.	.
1a: New product	1%	4%	6%	-3%	1%	9%	12%	13%	12%	12%	13%	20%	40%	44%	47%
1a1: New good	0%	4%	8%	2%	5%	6%	9%	11%	13%	14%	.	.	13%	11%	7%
1a2: New service	0%	0%	-1%	-4%	-2%	5%	3%	4%	6%	2%	.	.	.	.	.
1b: New process	5%	5%	-1%	-4%	-1%	5%	9%	16%	19%	17%	.	.	7%	12%	11%
1c: New organisation	-3%	1%	5%	0%	5%	14%	10%	12%	13%	13%	.	.	.	.	.
1d: New marketing	-5%	6%	7%	12%	11%	7%	9%	11%	11%	10%	.	.	.	.	.
Innovation trajectories															
2: New-to-the-mkt	11%	-1%	1%	1%	17%	-2%	-1%	0%	2%	2%	.	.	.	.	.
3: Prod in-house/coop	4%	4%	1%	4%	4%	5%	9%	6%	7%	7%	.	.	.	.	.
4: Proc in-house/coop	1%	-7%	-2%	-5%	0%	2%	4%	5%	4%	6%	.	.	.	.	.
5a: Org OR mrktg	-5%	5%	6%	10%	12%	8%	5%	5%	6%	5%	.	.	.	.	.
5b: Org AND mrktg	-9%	4%	0%	2%	7%	7%	7%	11%	13%	8%	.	.	.	.	.
5c: Org	-6%	1%	2%	-1%	7%	7%	3%	5%	6%	4%	.	.	.	.	.
5d: Mrktg	-9%	9%	4%	14%	14%	7%	9%	11%	12%	9%	.	.	.	.	.
6a: Prod AND mktg	-11%	3%	-1%	1%	8%	8%	7%	10%	12%	5%	.	.	.	.	.
6b: Proc AND org	-4%	5%	-1%	-5%	14%	12%	11%	19%	21%	14%	15%	.	24%	31%	35%
6c: Prod AND mktg/org	-7%	6%	1%	4%	8%	8%	7%	10%	11%	7%	.	-9%	.	.	.
6d: Proc AND mktg/org	-4%	8%	0%	-7%	5%	11%	10%	19%	20%	12%	16%	.	26%	33%	39%
Cooperation in innovation															
7: Coop	12%	4%	6%	4%	9%	5%	9%	6%	7%	7%	.	13%	29%	36%	45%
Data	Panel					Cross-section					Panel				
Estimation	Random Effects					Random Effects					Random Effects				
N. obs	1697					1993					1446				

Bold: significant at 10%; Underlined: significant at 5%; Double-underlined: significant at 1%; ".": non significant; <<blank>>: not available

Table 3 (continued)
Probability to innovate associate to the intensity of ICT use (number of IT links) - Services

	Italy					Luxembourg					Netherlands				
Number of IT links	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Innovation capabilities															
1: Any innovation	28%	62%	56%	64%	73%	3%	8%	7%	6%	6%	0%	1%	0%	-4%	1%
1a: New product	7%	25%	21%	23%	32%	36%	45%	40%	25%	42%	2%	3%	3%	-5%	1%
1a1: New good	6%	17%	9%	12%	20%	9%	8%	2%	6%	6%	4%	18%	39%	17%	26%
1a2: New service	4%	17%	17%	20%	23%	6%	13%	5%	-7%	10%	12%	5%	-2%	0%	-1%
1b: New process	11%	28%	25%	37%	36%	-6%	-2%	-3%	17%	23%	-9%	5%	-6%	2%	-5%
1c: New organisation	24%	43%	47%	52%	59%	2%	6%	8%	8%	-7%	-5%	-1%	-3%	2%	-9%
1d: New marketing	0%	10%	7%	7%	18%	3%	12%	17%	6%	2%	7%	12%	21%	19%	19%
Innovation trajectories															
2: New-to-the-mkt	1%	9%	-12%	-12%	0%	18%	9%	2%	10%	12%	-7%	-2%	-1%	-4%	1%
3: Prod in-house/coop	-7%	10%	15%	0%	7%	.	.	.	.	.	5%	-5%	6%	1%	0%
4: Proc in-house/coop	4%	3%	12%	10%	5%	.	.	.	.	.	-2%	-2%	2%	1%	9%
5a: Org OR mrktg	1%	-4%	0%	-1%	0%	1%	-10%	5%	-2%	-26%	-6%	-2%	1%	5%	-6%
5b: Org AND mrktg	-1%	3%	15%	11%	21%	-3%	13%	17%	-3%	2%	3%	8%	12%	12%	11%
5c: Org	2%	-7%	6%	3%	1%	-11%	-14%	-7%	-15%	-33%	-6%	-1%	-3%	5%	-10%
5d: Mrktg	-2%	4%	8%	5%	17%	3%	15%	24%	5%	3%	6%	11%	21%	20%	18%
6a: Prod AND mktg	-12%	2%	-1%	6%	4%	-11%	14%	10%	-27%	-2%	-4%	-5%	3%	7%	6%
6b: Proc AND org	3%	3%	9%	15%	11%	-5%	2%	-5%	6%	4%	-8%	0%	-8%	8%	-2%
6c: Prod AND mktg/org	-5%	1%	1%	4%	7%	9%	2%	6%	-4%	-7%	-3%	4%	4%	1%	-3%
6d: Proc AND mktg/org	0%	3%	10%	10%	13%	-6%	7%	-2%	4%	10%	-6%	1%	-7%	8%	-2%
Cooperation in innovation															
7: Coop	2%	-2%	-2%	3%	1%	3%	3%	9%	8%	5%	1%	4%	3%	-2%	7%
Data	Cross-section					Cross-section					Panel				
Estimation	Random Effects					Random Effects					Random Effects				
N. obs	1912					210					235				

	Norway					Spain					United Kingdom				
Number of IT links	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Innovation capabilities															
1: Any innovation	15%	13%	11%	14%	22%	15%	23%	21%	18%	23%	.	.	6%	.	.
1a: New product	11%	7%	17%	10%	18%	2%	2%	7%	1%	6%	10%	11%	18%	22%	21%
1a1: New good	3%	5%	13%	5%	8%	0%	1%	5%	2%	6%	4%	4%	6%	7%	7%
1a2: New service	6%	-1%	2%	8%	8%	3%	2%	7%	3%	6%	.	.	.	.	.
1b: New process	3%	4%	8%	12%	24%	12%	19%	20%	18%	21%	.	.	.	-6%	.
1c: New organisation	11%	4%	8%	7%	15%	10%	14%	7%	13%	19%	.	.	.	.	.
1d: New marketing	2%	5%	10%	17%	20%	-1%	4%	2%	5%	11%	11%	18%	24%	29%	32%
Innovation trajectories															
2: New-to-the-mkt	13%	17%	8%	15%	1%	-1%	14%	13%	2%	22%	.	.	.	.	.
3: Prod in-house/coop	1%	-2%	-6%	-8%	-8%	5%	-14%	-2%	-4%	2%	.	.	.	.	.
4: Proc in-house/coop	-4%	-12%	3%	-1%	-5%	1%	-1%	9%	13%	1%	.	.	.	.	.
5a: Org OR mrktg	-4%	-2%	1%	5%	3%	-1%	-1%	-11%	-2%	4%	.	.	.	.	.
5b: Org AND mrktg	0%	-6%	11%	8%	14%	-9%	-5%	-6%	4%	8%	.	.	.	.	.
5c: Org	5%	-5%	4%	-3%	3%	0%	-3%	-12%	0%	4%	.	.	.	.	.
5d: Mrktg	-9%	-2%	7%	16%	13%	-10%	-4%	-7%	0%	7%	.	25%	31%	41%	45%
6a: Prod AND mktg	-14%	-8%	0%	4%	19%	-2%	-5%	-3%	-2%	7%	.	.	.	.	-8%
6b: Proc AND org	4%	1%	12%	9%	26%	4%	9%	-1%	11%	14%	.	.	.	.	-
6c: Prod AND mktg/org	-1%	-1%	20%	11%	17%	6%	-5%	-1%	-4%	6%	15%	21%	27%	29%	31%
6d: Proc AND mktg/org	-6%	-1%	8%	8%	25%	4%	10%	3%	12%	18%	.	.	.	-8%	.
Cooperation in innovation															
7: Coop	1%	1%	5%	-2%	1%	4%	12%	12%	16%	19%	.	.	.	.	.
Data	Panel					Cross-section					Panel				
Estimation	Random Effects					Random Effects					Random Effects				
N. obs	1273					1336					2630				

Bold: significant at 10%; Underlined: significant at 5%; Double-underlined: significant at 1%; ".": non significant; <<blank>>: not available

- *ICT use increases the probability to introduce a new organisation*

The number of web facilities increases the probability to innovate for the manufacturing firms in 5 countries out of 8. The increase is the highest in Italy, where firms with three web facilities are 43% more likely to innovate in organization than firms with no web facilities. In Canada, the United Kingdom, the Netherlands and Spain the increase is 24%, 19%, 16% and 13%, respectively. Firms with two web facilities in Luxembourg are 40% more likely to innovate, although the effect becomes not significant for a higher number of facilities.

These effects are confirmed for services in 4 countries out of 7. The increase is the highest in Spain and Italy, where firms with three web facilities are, respectively, 46% and 43% more likely to introduce a new organization than firms with no web facilities. In Norway and the United Kingdom the increase is 19% and 23%, respectively.

- *ICT use increases the probability to innovate in marketing*

The number of web facilities increases the probability to innovate in marketing for the manufacturing firms in 6 countries out of 8. The increase is the highest in Italy and the Netherlands, where firms with three web facilities are 38% and 36%, respectively, more likely to innovate than firms with no web facilities. The increase is 29% in Canada, 18% in Norway and the United Kingdom, and 16% in Spain. Firms with two web facilities in Luxembourg are 23% more likely to innovate in marketing, although the effect becomes not significant for a higher number of web facilities.

The number of web facilities increases the probability to innovate in marketing for the service firms in 5 countries out of 7. The increase is the highest in the Netherland, where firms with three web facilities are 38% more likely to innovate than firms with no web facilities. In the remaining countries this effect seems weaker than in manufacturing. The increase in the probability to innovate in marketing is 22% in Norway, 18% in the United Kingdom, 14% in Italy and 10% in Spain.

6.2 Trajectories in innovation

- *ICT use does not increase the probability to introduce a product new-to-the-market*

The introduction a new product by a firm may result from the adoption of an existing product, *i.e.* new-to-the-firm, or by the invention of a truly new product, *i.e.* new-to-the-market. If ICT use increased the invention capabilities of a firm, one may expect new products by ICT intensive users to be new-to-the-market more often than new-to-the-firm.

Against this expectation, we found that ICT use does not increase the probability to introduce a product new-to-the-market – as opposed to new-to-the-firm. Manufacturing firms in Switzerland are the only ones to show a higher probability (10%) although the statistical significance of this result is weak (10%).

- *ICT use does not increase the probability to develop a new product or process in-house*

The introduction a new product or process by a firm may result from the adoption of an existing product/process developed by another firm or by the invention of a new product/process developed in-house. If ICT use increased the invention capabilities of a firm, one may expect new products/process by ICT intensive users to be mostly developed in-house (or in cooperation with other firms).

In general, we found little evidence that ICT use increases the probability to introduce a new product or a new process developed in-house. Service firms in the United Kingdom are the only to show a higher probability (up to 19%) to develop a new product in house or in cooperation with other firms.

- *Among all innovative firms, ICT intensive users are more likely to innovate in organisation or marketing*

The number of web facilities increases the probability to innovate in marketing for the innovative manufacturing firms in 6 countries out of 7. The increase is the highest in the Netherlands, where innovative firms with three web facilities are 37% more likely to innovate in marketing than innovative firms with no web facilities. The increase is over 20% in Canada, Italy and Norway and it is 17% and 15% in Spain and the United Kingdom, respectively. In this latter country, the probability to innovate both in process and marketing/organization increases up to 40%.

In the service industries, the intensity of ICT use increases the probability to innovate in marking among innovative firms in the Netherlands (40%) and Italy (18%). In the United Kingdom, ICT use increases the probability to innovate in process and marketing/organisation (38%) as well as in product and marketing/organisation (32%).

6.3 Cooperation in innovation

- *ICT use does not increase to probability to cooperate in innovation*

In general, we found little evidence for the hypothesis that ICT intensive users are more likely to cooperate in innovation with other firms or institutions. The only firms where ICT use is associated to a higher probability in to cooperate in innovation are manufacturing firms in the United Kingdom (16%) and services firms in the Netherlands (22%).

7 Conclusions and suggestions for further research

This study has tried to assess the effects of information and communications technologies (ICTs) as an enabler of innovation in eight OECD countries. Our findings support the hypothesis that ICTs act an enabler of innovation, in particular for product and marketing innovation. Unlike previous studies, our results show that these effects are large both in manufacturing and services.

However, we did not find any evidence that ICT use increases the capability of a firm to cooperate with other firms/institutions nor that ICT intensive firms have higher capacity to develop innovation in-house or to introduce more "innovative" (new-to-the-market) products. These results suggest that ICTs enable firms to adopt innovation but they not increase their "inventive" capabilities, *i.e.* the capability to develop new products and processes.

In interpreting these results, one should bear in mind that they are based on some "imperfect" measure of ICT use by firms. As discussed above, firms with the same automatic IT links or web facilities may use them differently and our indicators would not capture these differences. In addition, these indicators seem biased towards the use of ICTs for e-commerce and e-business but they may be a poorer proxy for other ICT-enabled activities relevant for innovation, eg: communication.

One development of the present study, therefore, would be to test the above results against some alternative indicator of ICT use. For instance, the analysis could be repeated using ICT investments for the few countries where data are available at the firm level.

If the results were confirmed, another development of the present study would be to have researchers from additional countries to joint the network and apply the research model developed for this study. In this sense, cooperation with the WPIE could be useful to reach a larger set of potential contributors to this project.

Another direction for further research would be to link the present results to an analysis of productivity at the firm level. Do ICT-enabled innovations have a different impact on productivity as compared to other types of innovation? Do they act through different channels? This line of research requires linking ICT and innovation micro data to business registers or business surveys and introducing ICT variables into a broader productivity model.

The analysis of productivity at the firm level is currently carried out by an international research network related to two OECD bodies, NESTI and WPIA. Therefore, it seems opportune to explore the scope for joint work with these two working parties.

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Innovation: the link between ICT and productivity growth[5]

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Abstract

We present two pieces of empirical evidence related to sources of differences in productivity growth. One piece of evidence is at the micro level, the other at the macro level. Using a growth accounting type of analysis, we show that the productivity gap between the United States and the European Union can be explained by differences in the strength of the emergence of the knowledge economy: the United States have seen higher investments in ICT capital, and have enjoyed a higher growth of multifactor productivity, which is a sign of higher technological progress. Using Dutch firm level data, we show that at the micro level, productivity differences are mainly explained by organizational innovation. Moreover, these organizational innovations are driven by investment in ICT. Taken together, we argue that these pieces of empirical evidence indicate that US firms have benefited from higher investments in ICT, which have allowed them to be more innovative especially in the organizational area, and consequently be more productive than their European counterparts.

[5] This paper is an extended version of a chapter in the Statistics Netherlands 'Kennis en Economie 2009' (Polder and Van Leeuwen, 2010). The empirical results in this paper are sourced from the chapter mentioned and Polder, Van Leeuwen, Mohnen and Raymond (2010). I thank Mariagrazia Squicciarini and Kristina Nyström for comments. Any errors are my responsibility. The views expressed in this paper are those of the author and do not necessarily reflect any policy by Statistics Netherlands.

1 Introduction

What is the reason that a certain firm is more productive than another? That is a question to which many policy makers and economists are seeking to get an answer. And why are there differences in productivity among countries? For example, why are the United States in many statistics more productive than the European Union? To get an answer to these questions one must look for the sources of productivity growth. The usual suspects include investment in ICT and its application, the degree of innovation, organizational skills, the quality of labour et cetera. In this paper we look at this question from both a macro- and a micro-economic perspective. We go into the macro-economic explanations given for differences in productivity among countries (in particular between the US and the EU). We use EUKLEMS data to illustrate these findings using an update of a decomposition analysis similar to Van Ark et al. (2008). This shows that the rise of the knowledge economy in the EU has been relatively slow, especially with respect to the adoption of ICT and technological changes. Next, we briefly discuss the apparent analogy between the micro-economic literature on ICT driven organizational innovation on the one hand, and R&D driven technological innovation on the other. We then present some of the findings in Polder et al. (2010), who combine these strands of literature and go into the issues of the relative importance of ICT and R&D for innovation, the relative importance of different types of innovation and the complementarity among these types. The study shows that ICT contributes to innovation success, especially in the services sector. ICT is most important for organizational innovation. R&D, however, is mainly important for successful product innovation in the (more traditional) manufacturing sector. Innovation, at its turn, is an important factor in explaining productivity differences between the firms. Especially organizational innovation seems to contribute to firm performance. Technological innovations also have a positively effect, but only when there is also an organizational innovation. The picture that emerges is that ICT should be seen as an important driver of organizational changes, where these latter changes at their turn make an important contribution to productivity growth at the firm-level.

Putting the micro- and macro-economic pieces of evidence together, points at the possibility that a higher ICT adoption has enabled US firms to be more innovative, especially in the organizational area, which, combined with the relatively stronger shift towards a services oriented economy, offers a tentative explanation for the existing productivity differences between the US and the EU15.

The paper is organized as follows. Section 2 presents descriptive evidence for sources of productivity differences between the US, the EU15, and in particular the Netherlands, since our micro analysis focuses on this country. We follow the growth accounting approach using the EUKLEMS database. Section 3 discusses briefly two streams of empirical studies on the sources of productivity growth and differences at the firm-level. Subsequently, in section 4, we present a model used in our earlier work (Polder, Van Leeuwen, Mohnen, and Raymond, 2010), which combines the existing two lines of the literature discussed. Section 5 gives the empirical results based on this model applied to Dutch firm-level data. Finally, section 6 provides a synthesis of the macro and micro evidence presented, giving a tentative further insight into differences in productivity growth on both sides of the Atlantic.

2 International differences in productivity growth

For quite some time economists have been debating about reasons for the divergence in productivity growth between the US and EU15, especially since the mid 1990s. Van Ark et al. (2008) show that this is “attributable to the slower emergence of the knowledge economy in Europe compared to the United States” (op. cit. p. 25). Manifestations of this observation are the lower investments in and production of ICT, a slower technological progress and a relatively less important role for the services sector. To illustrate these points, we reproduce two of their analyses here using the updated EUKLEMS database with data until 2007 (the original article considers data until 2004). We also include the Netherlands in the tables, since our micro analysis below uses Dutch data.

Table 1 shows the decomposition of economic growth in the EU (measured by the 15 member states prior to 2004)[6], the US and the Netherlands. The economic growth can be decomposed in two components: the (change in) hours worked (i.e. the volume component of the contribution of labour) and the change in labour

[6] In fact, the data concern ten countries of the former EU15 for which the variables for this analysis are available.

productivity (i.e. the part of the volume change that cannot be attributed to the change in labour). The latter component can be further decomposed in a part that refers to the composition (i.e. quality) of the labour force, capital intensity of the production process, and multifactor productivity (mfp). The change in mfp is in fact a residual term that cannot be attributed to one of the other components, and is often interpreted as a measure of the technological progress.

Table 1 shows that the US displayed a higher economic growth in the periods considered. In the second period the difference with the EU has become somewhat smaller: from 1.2% to 1.0%. The Netherlands recovered more of its gap, going from 1.0% to 0.4%. In the period 1995-2007, the difference between the US and the EU is mainly due to the difference in the growth of labour productivity: where the growth in hours worked was similar (0.6% vs. 0.5%), the growth in labour productivity was 3.0% in the US against 1.9% in the EU, down from 2.4% in the previous period. On the other hand, the Netherlands was able to increase its labour productivity to 2.4%, making it possible to increase its economic growth and recover some of its arrears. When we then look at the components making up the change in labour productivity, it turns out that the difference there is mainly caused by a lower growth of mfp, or in other words a slower technological change in the EU. This does not hold for the Netherlands: its mfp growth is comparable to the US. As in the rest of the EU the growth in ICT capital stays behinds in the Netherlands, however, which is another important reason explaining the lower growth of labour productivity in the EU and the Netherlands compared to the US. Van Ark et al. suggest that the contribution of the knowledge economy can be measured by the sum of the (growth in) quality labour, ICT capital and mfp. Although in the first period the EU performed similar to the US, it is clear that the latter have performed better in the second period in this respect. The Netherlands are well above average in the EU, but remains behind the US.

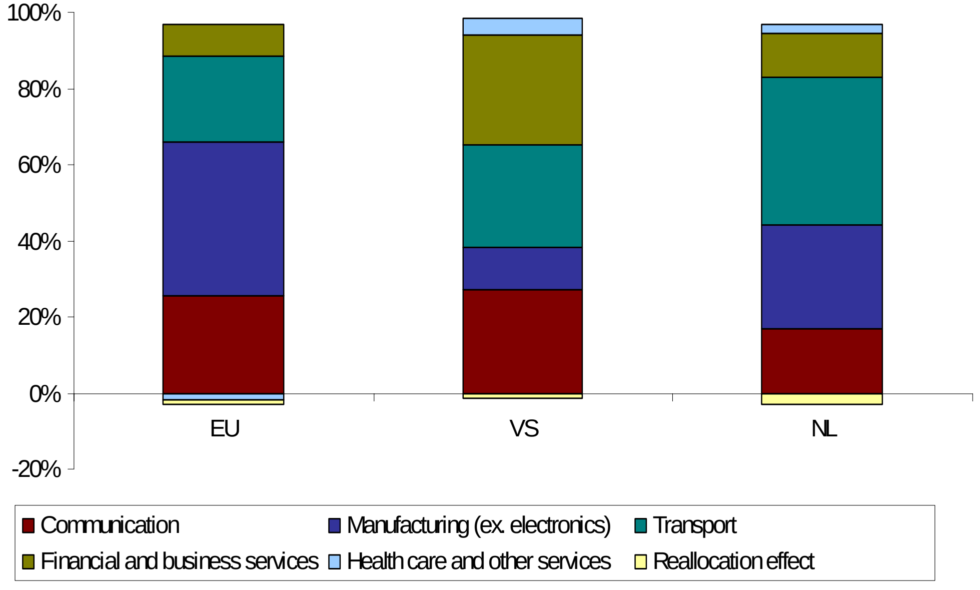
Table 1
Contributions to economic growth in the EU-15, US and the Netherlands, 1980-2007

		EU-15		VS		NL	
		1980-1995	1995-2007	1980-1995	1995-2007	1980-1995	1995-2007
		%					
(1) volume growth market economy	(2) + (3)	2.1	2.5	3.3	3.5	2.3	3.1
(1) is composed of:							
(2) hours worked		-0.3	0.5	0.8	0.6	0.7	0.7
(3) labour productivity	(4) + (5) + (8)	2.4	1.9	2.4	3	1.6	2.4
(3) is composed of:							
(4) labour composition		0.3	0.2	0.2	0.3	0.2	0.4
(5) capital services (per hour)	(6) + (7)	1.1	1.1	1.4	1.5	1.1	0.9
(6) ICT capital services (per hour)		0.4	0.5	0.8	1	0.5	0.6
(7) other capital (per hour)		0.7	0.6	0.6	0.5	0.6	0.3
(8) multifactor productivity		1	0.6	0.8	1.2	0.3	1.1
Contribution of knowledge economy	(4) + (6) + (8)	1.7	1.3	1.8	2.5	1	2.1

Source: EUKLEMS database, November 2009.
Some summations may not be exact due to rounding.

The EUKLEMS database also allows decomposing the change in labour productivity in the market sector into the contributions of different industries, as shown in figure 1. What this figure makes clear is that the US is relatively strong in the services sector. In particular, the transport and financial and business services stand out. These two sectors are both known to be ICT intensive. In the EU (and also in the Netherlands) we still see a relative big role for manufacturing. Together with the evidence in table 1, figure 1 illustrates the macro-economic findings that are often used as an explanation for the observed US-EU productivity gap: where the EU sees a relatively slow start of the knowledge economy and continues to have a relatively strong emphasis on manufacturing, the knowledge economy has grown far more in the US and the heart of the US economy has moved to ICT intensive services sectors.

Figure 1
Contribution per industry to labour productivity growth in the market sector (1995-2007)



Source: EUKLEMS database, November 2009.

In terms of the US-EU comparison, our results are very similar to those of Van Ark et al. (2008). For the US, Oliner and Sichel (2000) also attribute a large part of the growth resurgence in the second part of the 1990s to the 'high-tech revolution'. They find that much of the mfp growth is attributable directly to the production of computer hardware and semiconductors. Thus, besides the effect of ICT use on productivity, aggregate growth also comes for a large part directly from the productivity gains in the industries making computer related electronics. Although we look at the decomposition of labour productivity growth in figure 1, our numbers suggest that the importance of the productivity contribution of the ICT producing sectors has probably decreased from the beginning of the 21st century, since their contribution is comparable to that of financial business services and the transport sector. This is in line with the findings of Jorgenson et al. (2008). They suggest this could be due to a (temporary) cyclical upturn affecting the non-ICT sector more strongly. It appears, however, that the ICT *producing* sector has had trouble sustaining its accelerated pace in the late 1990s. At the same time, ICT *using* sectors have learned to exploit their ICT investments to its full potential, thereby becoming more efficient and increasing its importance relative to the ICT producing sectors. If adoption and learning with respect to new technologies takes time there may be a lag between the emergence of a general purpose technology and its gains (Basu et al. 2004).

Jorgenson et al. (2008) point to the micro-economic evidence for a deeper explanation of the link between technology and productivity. They note that to make ICT investments successful, complementary investment in innovations and organizational changes should take place. Although the macro-economic literature (e.g. Corrado et al. 2006) was unsuccessful in attributing the increased productivity growth to investments in intangible capital, a large body of micro-econometric studies suggests that there is such a link (e.g. Brynjolfsson and Hitt, 2000, Crépon et al. 1998). A possible explanation for the diversion in the empirical evidence at both levels of aggregation could be that the investments contribute indirectly to productivity, while growth accounting type of analyses concern the measurement of direct contributions through decomposition. Econometric modelling, on the other hand, aims to uncover the causal relation between variables. We turn to some micro-econometric evidence on the role of ICT and innovation in the next sections.

3 Two branches of empirical micro-economic productivity research

The evidence above shows that there seems to be a link between international (macro-economic) differences in productivity growth and the strength of the knowledge economy in the concerning countries. There is also an empirical micro-economic literature that investigates the relation between (firm-level) productivity growth and different aspects of the knowledge economy, e.g. innovation and technological progress. Within this literature there are roughly two (largely separated) branches. The first branch considers the effects on productivity of technological innovations that emanate from R&D activities. Rooted in the work by Griliches (see Griliches, 2000, for an overview), the most prominent model in this area is the CDM model, after the seminal paper by Crépon, Duguet and Mairesse (1998). Research based on this model using firm-level data from various countries shows that doing more R&D leads to (technological) innovation, which in turn has a positive effect on the productivity of firms (see e.g. OECD, 2009, for an internationally harmonized study, including the Netherlands and other EU member states).

Another literature focuses on organizational innovation, which are driven by investment and new developments in ICT. By organizational innovation is meant the improvements in the organization (*casu quo* management) of the production process, like the integration of supply chains, the introduction of knowledge and quality management systems, reallocation of business processes (including outsourcing), et cetera (see Murphy, 2002, for a more extensive treatment and more examples). Note that this type of innovation is different from technological innovation which concerns improvements in the actual production process (process innovation) or its product (product innovation). Empirical findings (e.g. Brynjolfsson and Hitt, 2000) show that ICT plays a vital role in developing and implementing these organizational innovations and that the latter have a positive effect on the productivity of a firm.

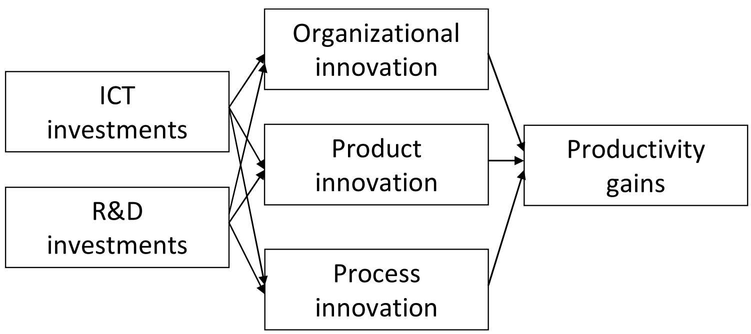
Strikingly, the conceptual models used by this literature have a similar structure: innovation input (investment in R&D or investment in ICT) leads to innovation output (technological innovation or organizational innovation) which ultimately lead to productivity gains. Despite this apparent analogy, no attempts have been made (to our knowledge) at combining these two approaches.

4 An encompassing model

As described in section 3, the micro-economic literature shows two ways to productivity growth: one via R&D driven technological innovation and one via ICT facilitated organizational innovation. A natural question that comes to mind is whether there are any interactions between these two routes? For example, one might rightfully ask whether ICT stimulates product innovation, or whether, in a way, doing R&D can be good for organizational innovation. Also, one could be interested in whether the different types of innovation could strengthen (or weaken) each other. To answer these questions requires the merging of the two lines of literature described above. Figure 2 gives a schematic overview of such a model, which we apply to data for Dutch firms in this paper.

As depicted in figure 2, the model aims to explain firm-level innovation from variables concerning R&D and ICT. We therefore refer to R&D and ICT also as innovation inputs. R&D is measured as the total of investment in R&D (intra- plus extramural) scaled by the number of (full-time) workers. With respect to ICT we distinguish between investments in ICT and the usage of ICT. As for R&D, investments in ICT are measured per worker. The intensity of ICT usage is measured by access to broadband (percentage of total workers) and the use of e-commerce (percentage of sales and procurement in the corresponding totals). The three types of innovation are measured by binary variables, which equal 1 if the firm performed an innovation of the pertinent type, and 0 otherwise. Productivity is measured by real production over the number of workers. In the productivity equation we control for capital intensity by including total depreciation per worker as a proxy.

Figure 2
Schematic overview of estimation model



The estimation model has three stages, which are carried out separately for manufacturing and services:

1) Innovation input – In this stage we estimate separate equations for both R&D and ICT investment, relating them to various innovation variables and firm size. We use a type-II tobit procedure (Heckman) to correct for the fact that R&D or ICT is often not reported or recorded. This first stage is mainly intended to generate predictions for the (latent) R&D activities and ICT investment to be used in the knowledge production function. There are two reasons to use these predictions. Firstly, innovation inputs may be endogenous to innovation success. Using predictions based on exogenous variables instead, controls for the possible associated bias. In addition, following Griffith et al. (2006), we predict the inputs for all firms with the idea that each firm has some degree of innovation activity even if it is not reported or unobserved. This may for example be the case with informal R&D or own development of software. A convenient

feature of this approach is also that there is no selection bias due to the fact that R&D and (non-zero) ICT investments are only observed for a subsample of firms.[7] (Although obviously there may still be selection bias resulting from the method of sampling of the survey data itself, for example the overrepresentation of larger firms.)

2) Innovation output (knowledge production) – The innovation output (or 'knowledge production') part of the model is a set of three equations with three dependent variables: product, process and organizational innovation. Since we only observe whether a firm has performed a particular type of innovation, and thus each dependent variable is a binary variable, the equation is a limited dependent variable model. We model the probability for the innovations as a three equation system with correlated (normal) errors. This results in a trivariate probit, which we estimate by (simulated) Maximum Likelihood. The explanatory variables include the (predicted) R&D and ICT investment from the first stage, as well as indicators for the usage of ICT: the intensity of access to broadband and e-commerce. We use bootstrapped standard errors for inference to account for the fact that predicted variables are used. Because innovation is likely to be endogenous to firm performance, we again construct predictions to be used in the production function estimation in stage 3. From the estimated knowledge production equation, propensities can be predicted for each possible combination of innovation types (with three innovation types, this amounts to 8 predicted propensities; we use the case where a firm does not perform any of the innovation as the reference category).

[7] This assumption is also implied by the estimation of the model in the original CDM-paper (Crépon et al. 1998). Latent innovation input is assumed to affect innovation output, and latent innovation output affects productivity. They use an Asymptotic Least Squares (ALS) estimation procedure, in which latent explanatory variables are replaced by their (linear) parameterizations. To illustrate, consider the model $y^* = \beta x + \varepsilon$, and $z = \alpha y^* + \omega$, where we observe $y = y^*$ only according to some selection rule. To estimate α, we may substitute y^* in the equation for z, and estimate first the reduced form $z = \gamma x + u$. If x is available for the whole sample (or it makes sense to set missing values to zero) we can use the whole sample for the estimation, not just the observations for which y^* is observed. If we have a consistent estimate of β, we can estimate α by minimum distance estimation from β and $\gamma = \alpha{\cdot}\beta$ (note that the estimation of β does require a method that controls for sample selection, which – as in our implementation – in the original CDM model is a type-II tobit estimation of the innovation input equation).

3) Productivity equation – The third and final stage concerns the OLS estimation of a (Cobb-Douglas) labour production equation augmented with dummies for each combination of innovation types. This allows drawing conclusions about which combinations contribute to productivity or not. Since the innovation dummies are endogenous, we replace them by the predicted propensities from stage 2. The estimation equation is therefore (suppressing subscripts for firms and years)

   $$Y/L = \alpha + \sum_j \gamma_j p_j + \beta_K K + \beta_L L + \varepsilon$$

   where Y is real output, L is number of workers, p_j is the predicted propensity of combination j (the actual estimation also includes industry and year dummies). This formulation also makes it possible to test for complementarity and substitutability (see e.g. Mohnen and Röller, 2005). By controlling for capital intensity (proxied by depreciation cost per worker) we avoid that the results are driven by 'capital deepening'. That is, it is likely that innovative firms are more capital intensive due to past investment in R&D and ICT, and therefore also achieve a higher value added and labour productivity, while this is not the consequence of innovation but merely of the fact that the firm has more capital available. Controlling for capital intensity in the analysis guarantees that the effects we measure are attributable to innovation. We also include firm size as an explanatory variable to allow for deviations from constant returns to scale. Again we use bootstrapped standard errors because of the use of predicted explanatory variables.

5 Results for Dutch firms

We will discuss only the results of the innovation and productivity equations here (i.e. stage 2 and 3). The results are taken from Polder et al. (2010). The interested reader can find the full set of results and a more extensive discussion of the data and methodology in the original paper. We use (biannual) Community Innovation Survey (CIS) data for the years 2002-2006 (three waves), which we link to the Production Statistics (PS, with information on firm inputs and output), ICT-survey (with information on broadband, e-commerce), and Investment Statistics (IS, with information on ICT investment). It is worth noting that innovation variables (except R&D) usually refer to a three-year period, while the information in the other surveys typically concern a single year. In the case of the augmented production function, this means we are relating productivity to whether firms performed a particular combination of innovations in the previous three years. Given that innovation may take time to materialize into productivity gains, this seems a reasonable approach. In the innovation output equation, we are relating the probability for an innovation in the previous three years to the investment in R&D in ICT in the current year. Of course, R&D and ICT investment in year t will not bare direct relation to innovation in t–1 or t–2. The main reason for using year t innovation inputs instead of lags, however, is that using lagged R&D and ICT investment results in very small estimation sample due to attrition, non-response, and the fact that smaller firms are not sampled in all years. However, we restrict the definition of R&D performers to firms that have stated to be continuous R&D performers, so that in principle the firms for which we use the R&D investment in our data can be expected to have invested in t-1 and t–2 as well. For ICT investment we assume that the investment in year t is indicative for the sum of the investments in the three-year period t–2 to t.[8]

5.1 The probability of innovating

Table 2 shows the qualitative results of this exercise, which offer a number of interesting conclusions:

- R&D increases the probability of product innovation in manufacturing, but not in services;
- R&D does not increase the probability of process and organizational innovation;
- investment in ICT increases the probability of an organizational innovation;
- investment in ICT increases the probability of a product and/or process innovation in services, but not in manufacturing;
- the usage of ICT (broadband access, e-commerce) increases the probability of all types of innovation in services;
- the usage of broadband increases the probability of product innovation in manufacturing, while e-commerce increases the probability of process innovation.

[8] In the bigger paper, we investigated the sensitivity of the results to using lagged (t-1) innovation inputs, although we could not do the estimation by sector due to a smaller number of observations. The main conclusions are maintained in this case.

Overall, it can be concluded that R&D contributes to innovation, although its contribution is restricted to product innovation in manufacturing. By contrast, the investment and usage of ICT have a positive effect on both technological as organizational innovation in both sectors, with stronger effects in services. This shows that various manifestations of ICT in both sectors create the infrastructure that equips firms to improve their ability to innovate. The limited role of R&D also puts into perspective its widespread use as innovation indicator for the whole economy. This observation is reinforced by the fact that most Western countries are moving towards a services oriented economy, thereby shifting away from R&D as the central force behind innovation.

Table 2
Marginal effects continuous variables for the knowledge production function

	product innovation		process innovation		organizational innovation	
Manufacturing (*N* = 2574)	ME	se (bs)	ME	se (bs)	ME	se (bs)
R&D[a]	0.411**	0.172	0.215	0.141	-0.014	0.109
ICT[a]	0.409	0.497	0.491	0.416	0.577*	0.326
broadband intensity[b]	0.109**	0.049	-0.012	0.029	0.145***	0.027
e-purchases[c]	0.042	0.140	0.159*	0.093	0.096	0.115
e-sales[c]	0.055	0.079	0.154***	0.046	-0.020	0.061
Services (*N* = 4913)						
R&D[a]	-0.209	0.254	-0.104	0.133	-0.166	0.175
ICT[a]	0.830***	0.240	0.411***	0.127	0.612***	0.168
broadband intensity	0.111***	0.017	0.030**	0.012	0.109***	0.026
e-purchases	0.100***	0.020	0.025*	0.015	0.090*	0.050
e-sales	0.082**	0.032	0.025	0.016	0.064	0.053

a) Predicted investment in 1000 of euros per fte (logs).
b) Percentage of broadband enabled workers.
c) Percentage in total purchases/sales.
Dependent variables: dummies for product, process and organizational innovation. All equations also include size, industry and year dummies that are not reported. Significance levels: *** = 1%, ** = 5%, * = 10%, based on bootstrapped standard errors.
[Source: Polder, Van Leeuwen, Mohnen and Raymond, 2010, table 3b].

Table 3
Estimation results by industry for the augmented production function

	manufacturing (N = 1992)		services (N = 3319)	
	coeff	se (bs)	coeff	se (bs)
Capital intensity	0.207***	0.013	0.250***	0.011
Employment	-0.013	0.018	-0.233***	0.014
TP(0,0,1)	1.654***	0.491	4.345***	0.571
TP(0,1,0)	-0.905	1.100	-2.703	1.943
TP(0,1,1)	0.984*	0.537	17.114***	2.213
TP(1,0,0)	0.468	0.300	0.808	1.275
TP(1,0,1)	-0.015	0.455	-0.804	0.705
TP(1,1,0)	-0.130	0.400	-8.327***	1.262
TP(1,1,1)	0.891***	0.193	3.932***	0.459
R^2	0.31		0.36	

All specifications include industry and time dummies. Dependent variable is log value added per fte. Capital intensity (depreciation per fte) and employment (fte) are in logs. Significance levels: *** = 1%, ** = 5%, * = 10%. TP refers to the combinations of innovation types: the combinations (0/1, 0/1, 0/1) reflect whether a firm has a product, process and/or organizational innovation. The dummies for combinations of innovation types are replaced by predicted propensities from the trivariate probit knowledge production function.
[Source: Polder, Van Leeuwen, Mohnen and Raymond, 2010, table 3c].

5.2 Productivity effects of innovation

Table 3 shows the results based on the estimation of the augmented production function, with the predicted propensities as explanatory variables in addition to capital and labour. Since we use the case where firms do not carry out any of the innovation types as a reference category (the (0,0,0) case), the coefficients should be interpreted as the additional productivity compared to not being innovative. As table 3 indicates, not all combinations lead to higher productivity. In fact, the combinations that increase productivity significantly always involve organizational innovation. This holds in both manufacturing and services. Thus, this type of innovation seems to have the strongest productivity effects. Product and process innovation also have a positive effect, but only when combined with organizational innovation. This finding indicates the relevance of including organizational innovation in the analysis, where other studies have typically ignored its role in combination with technological innovation. Thus, this puts into perspective earlier empirical work finding positive effects of product and/or process innovation, which as our results indicate could well be conditional on the presence of organizational innovation. One combination leads to a significant decrease in productivity in services, which is the combination of product and process innovation. An explanation could be that the production process is initially disrupted by these innovations, since they cost time and the effort and need to adapt to the new situation may initially prevent the firm from reaping the benefits of innovation.

5.3 Complementarity and substitutability

The fact that technological innovation is only associated with higher productivity when organizational innovation is involved, suggests that there may be complementarities between the different types of innovation. Moreover, there may be additional complementarity between product and process innovation.

We define complementarity as the existence of productivity gains from a combination of innovation, compared to the situation where only one of the two is performed. There are three types of complementarity to investigate:

1) between product and organizational innovation
2) between process and organizational innovation
3) between product and process innovation

There are various reasons why these complementarities could arise (see e.g. Milgrom and Roberts, 1990, and Athey and Schmutzler, 1995, for theoretical underpinnings). One way in which these may occur, is when the introduction of a certain innovation lowers the cost (or increases the benefit) of another innovation. For example, the introduction of a more flexible production structure (through process innovation) could imply that it becomes easier or more cost efficient to alter the physical product of a firm (product innovation) or improve the scope for e.g. quality control and the outsourcing of business functions (aspects of organizational innovation under our definition). Improvements in workplace organization (organizational innovation) may foster creativity and thereby lead to new or improved products or processes. The introduction of a new product line or production process may require additional skills by workers, which increases the value of the management of knowledge sharing and educational programs.

The other side of the coin is that joint introduction of innovations may be counterproductive, i.e. it leads to lower productivity than would have been the case when one of the innovations were introduced. This phenomenon is usually referred to as ‘substitutability’ in the literature, as opposed to the ‘complementarity’ discussed above. We shall also use the term substitutability in this way, although we want to note that this does not imply that two types of innovations are actually substitutes in the sense that they are mutually interchangeable. Firstly, it goes without saying that the nature of the types of innovation is very different and the firm chooses the innovation which fits its purposes. Moreover, substitutability between two innovation types implies that the introduction of *one* of the innovation types is better than a joint introduction. It does not have to be that both types of innovation are equally profitable, or in other words, that the firms should be indifferent between them. In this respect, the term substitutability is perhaps confusing, but with these caveats in mind we will use it as is common in the literature.

Evidence of substitutability in our context could mean that a firm is better off spreading its changes, rather than concentrating them into a short period of time. This is the case when marginal adjustment costs are increasing with the size of adjustments. For example, large adjustments in the production process may require retraining of the work force, which may work better if these workers do not have to get used to, for example, any unrelated but significant changes in the organization. In general, in the face of large innovation projects requiring a large coordination effort, a firm may find it worthwhile to implement these innovations in different phases.

To test for these complementarities (and possibly substitutability) we perform a test similar to that in Mohnen and Röller (2005), which is a special case of a more general test originally suggested by Kodde and Palm (1986). The test requires the re-estimation of the productivity equation, now including the combination (0,0,0), i.e. the propensity for a firm not having done any of the innovation types, and consequently dropping the constant to avoid multicollinearity.[9] Let

j = {1[product innovation], 1[process innovation], 1[organizational innovation]},

the vector of dummies indicating the types of innovation of a particular firm. Then, the additional productivity (compared to the case of no innovations) associated with combination j is $\gamma_j - \gamma_{000}$. Complementarity of, for example, product and process innovation,

[9] The coefficient γ_{000} could be deduced from the previous results but the test also requires the covariance matrix for all γ_j's.

requires that the additional productivity of the joint introduction is higher than the sum of the combinations where they are not combined. There are then two restrictions, according to whether there is an additional organizational innovation or not:

$$\gamma_{110} - \gamma_{000} \geq (\gamma_{100} - \gamma_{000}) + (\gamma_{010} - \gamma_{000}) \quad \Leftrightarrow \quad \gamma_{110} + \gamma_{000} \geq \gamma_{100} + \gamma_{010}$$

and

$$\gamma_{111} - \gamma_{000} \geq (\gamma_{101} - \gamma_{000}) + (\gamma_{011} - \gamma_{000}) \quad \Leftrightarrow \quad \gamma_{111} + \gamma_{000} \geq \gamma_{101} + \gamma_{011}$$

The inequalities for the complementarity among other types are derived in the same way. To test substitutability, one should flip the inequality signs. Kodde and Palm (1986) derive a test for such inequalities. The test statistic is given by

$$D = (S\tilde{\gamma} - S\hat{\gamma})'(S'\,\mathrm{cov}(\hat{\gamma})S)^{-1}(S\tilde{\gamma} - S\hat{\gamma}) \text{ with}$$

$$\tilde{\gamma} = \arg\min\,(S\gamma - S\hat{\gamma})'[S'\,\mathrm{cov}(\hat{\gamma})S]^{-1}(S\gamma - S\hat{\gamma}) \text{ s.t. } S\gamma \leq 0$$

where $\hat{\gamma}$ the OLS estimate of γ, $\mathrm{cov}(\hat{\gamma})$ is the estimated covariance matrix of γ, and S is a matrix that maps the coefficients into the constraints derived above. For example, if one wants to test jointly the constraints associated with complementarity for product and process innovation,[10]

$$S = \begin{bmatrix} -1 & 0 & 1 & 0 & 1 & 0 & -1 & 0 \\ 0 & -1 & 0 & 1 & 0 & 1 & 0 & -1 \end{bmatrix}.$$

The covariance matrix can be estimated from the OLS results. The interpretation of $\tilde{\gamma}$ is that it is the coefficient, which is as close as possible to the OLS estimates under the restrictions reflected in S. We use quadratic minimization under inequality constraints in MATLAB to calculate $\tilde{\gamma}$. Critical values for the test statistic D can be found in Kodde and Palm.

Table 4 shows the outcome of the tests. We find evidence that process and organizational innovation are complements, but particularly in the services sector. There is some evidence that points

[10] Note that for testing submodularity the matrix is $-S$.

in the direction of complementarity in manufacturing, but the test remains inconclusive. Thus, it appears that there are synergies between the introduction of a new method of production and changes in the organization, at least in services. Product and process innovation are found to be complements in both sectors, pointing at the possible increase in marginal profitability of those types of innovation when the other type is carried out as well. Finally, we find that product and organizational innovation are substitutes in both sectors. As noted the word 'substitute' is perhaps confusing in this respect. The outcome of the test means that on average the joint introduction of product and organizational innovation leads to lower productivity than combinations where they are not introduced jointly. The test result does not imply, however, that one innovation type can be replaced by the other and that a firm should be indifferent between the two. In fact, the results in table 3 suggest that an organizational innovation by itself is probably better than an individual product innovation. As argued above, the result could implicate that the introduction of a new or improved product in times of reorganization could be hampering the success of the product innovation.

Table 4
Complementarity and substitutability of innovation types

Combination of innovations	Manufacturing	Services
Product/process	complements	complements
Product/organizational	substitutes	substitutes
Process/organizational	?	complements

Source: Polder, Van Leeuwen, Mohnen and Raymond, 2010.

6 Conclusion: micro-macro synthesis

In this paper we presented two analyses into the sources of differences in productivity growth between countries and firms. Although these analyses are on different levels of aggregation, and not directly related at first sight, it is possible to end with a tentative synthesis. Putting the two pieces of micro- and macro-economic evidence together, the following picture emerges.

The macro results suggest that differences in productivity growth between countries can be traced back to differences in the investment in ICT capital and the slower adoption of new technologies in general. The slower emergence of the knowledge economy, of which ICT and technological progress are aspects, is the main explanation for the observed productivity (growth) gap between the US and the EU. At the firm-level, it turns out that ICT is an important driver of innovation in general, but especially organizational innovation. This holds for both sectors, but is most important in services. Thus, ICT can be seen as a ‘general purpose technology’ that creates the infrastructure for the innovation process. R&D, traditionally considered to be an important driver of innovation, and still one of the main indicators of innovation used in international benchmark exercises, turns out to be important but mainly for product innovation in manufacturing, which happens to be also the type of innovation and segment of the economy where most of the empirical work traditionally focuses on. Our results show that the results from these studies cannot be generalized to whole economy, especially to the services sector, which is of growing importance in most developed countries.

In turn, innovation improves firm performance. Since only combinations that involve organizational innovation are found to increase productivity, it seems that this type of innovation is most important. Because we also found that organizational innovation benefits strongly from ICT, a tentative conclusion is that a higher adoption of ICT has enabled US firms to be more innovative, especially in the improving business organization. Moreover, at the macro-level this effect is reinforced by the fact that the US has displayed a stronger shift towards a services economy, thereby increasing even more the fraction of ICT intensive firms and scope for organizational innovation.

Thus, we find that ICT leads to better firm performance via innovation. We may label innovation as the link between ICT and productivity growth. Our findings point out the importance to acknowledge the different roles of ICT and R&D in the innovation process when thinking about firm investment and innovation policies. Moreover, given that the results differ between sectors, especially with respect to the drivers of innovation, policy design should take into account sectoral differences. Finally, given that the emphasis of R&D is on technological innovation in manufacturing, our results show that it is wise to go beyond R&D expenditures as a main indicator of innovation activities economy-wide.

Future efforts could go into refining the micro-econometric modelling of the relations we have investigated. Especially alternative timing assumptions and/or a more flexible dynamic model structure should be investigated. This could shed light into how innovation inputs, innovation outputs, and performance variables are mutually dependent in a dynamic sense. For example, feedback effects between innovation efforts and productivity ('success breeds success') may be expected. Moreover, one could make use of the panel structure of the data to control for unobserved firm heterogeneity. To the extent that omitted variables are more or less constant over time, this may also mitigate the effect of any missing variables, due to for example the lack of information on worker skills in our data. The introduction of firm-specific effects would complicate the econometrics, however, especially in the context of our multivariate discrete knowledge output equation.

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Human Capital Composition and Economic Performance of Industries: Evidence from OECD Countries

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1 Introduction

This paper is focused human capital composition and economic performance in OECD countries. Its aim is two-fold: to highlight new challenges for assessing the skill levels and to analyse the role of the skill composition differences as a determinant of labour productivity differentials across industries.

The importance of human capital accumulation for economic development is explored by many economists since Becker (1964). An important number of endogenous growth contributions (e.g. Lucas (1988), Romer (1990), Aghion-Howitt (1992)…) strongly emphasize the role of education as a key determinant of technological progress and economic growth.

Human capital is defined as all the capacities to contribute to production, generally called skills. Since the seminal article by Griliches (1969), the empirical literature is interested in testing hypotheses and explaining complex relations between skills and economic performance. At the firm level, today's knowledge-based economic context regards workers' educational attainment as a very significant signal with respect to his/her competencies and potential productivity.

Following in this direction, this papers aims to investigate at industry level the impact of the skill composition of employment on the labour productivity in OECD countries.

The remainder of this paper is organized as follows. A brief literature review is conducted in the Section II, followed by the presentation of the dataset used in this study and a set of descriptive statistics (Section III). Section IV provides empirical evidence on the relationship between the skill composition of employment and labour productivity and Section V concludes.

2 Literature review

Along with the OECD recommendation, human capital is regarded as being "the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being" (OECD, 2001a p.18). While the human capital literature emphasizes education or training as determinants of skills, a broader conception of skills is now recognised, accounting notably for learning-by-doing and on-the-job training, which underlines the relevance of the occupational dimension as well.

Assessment of skills involves indeed several dimensions. One component refers to the *educational attainment* and is developed widely since Schultz (1961). The concept of human capital takes a more comprehensive dimension referring to education, health and training of individuals (Becker 1964). In parallel, a number of analyses emphasized the *occupation* of individuals since many mechanisms of learning by doing take place once individuals are out of the educational system (e.g. Arrow 1962).

Statistically, educational attainment is often measured through literacy rates (Summers and Heston, 1991), school enrolment ratios (Levine and Renelt, 1992), average years of schooling (Barro and Lee, 1993, 1996, 2001; Krueger and Lindhal, 2001), and direct tests of cognitive skills (Hanushek and Kimko, 2000; Gundlach, Rudman and Wö mann, 2002), whereas on-the-job training is assessed as occupation requirements (Elias and McKnight, 2001).

However assessing skills is not an easy task since such quantification should ideally take into account many other subjective parameters. As a matter of fact, measurement of skills has been recognized as a major challenge for research on economic performance (see Borghans, Green and Mayhew, 2001; Le, Gibson and Oxley, 2003; and Wö mann, 2003 for surveys on measurement issues). As of today, weaknesses and lacks in international comparable and reliable data prevent robust cross-country analyzes (de la Fuente and Domenech, 2001). This paper builds on and complements several previous attempts to assess skills of working population (Psacharapoulos and Ariagada, 1986; Nehru *et al*. 1995, Barro and Lee, 2001).

Studies analysing productivity have been carried out within the OECD for a long time. A reference manual on measuring productivity (OECD, 2001b) presents the theoretical foundations to productivity measurement, discusses implementation and measurement issues, and provides guidelines for interpretation. As regards the recent analytical works of the OECD, among many others, one can notably find topics such as the impact of R&D on multifactor productivity (Guellec and van Pottelsberge de la Potterie 2001), productivity impacts of offshoring and outsourcing (Olsen 2006), measurement of multifactor productivity growth (Wölf and Hajkova 2007).

Over the last decade, emphasis has been put on skill assessment and the possible linkages to technological progress by Colecchia and Papaconstantinou (1996). More recently, the relationship between the broadly speaking sources of knowledge and productivity is investigated by Khan and Lutinel (2006). However, an important lack can be noticed today in terms of analysis putting emphasis on the importance of workers' skills while assessing the productivity differentials across countries and across industries.

3 Dataset and skill distribution of employment in OECD countries

3.1 The ANSKILL Database

Although complementarities of education and occupation variables have been strongly emphasized in the past, only a few papers resort to both proxies to account for human capital. One contribution of this paper is to assess skills through both the educational attainment (International Standard Classification of Education ISCED-97)[11] and occupations (International Standard Classification of Occupations ISCO-88) by industry (International Standard Classification of Industries ISIC Rev3). This is the main difference between this dataset and the EU KLEMS database[12], which considers educational attainment exclusively as being the skill proxy.

While considering occupation as a proxy of skills, the following skills associations are established on the basis of the ISCO-88.

[11] Resorting to the ISCED has been justified by Steedman and McIntosh (2001). Under some assumptions, these authors demonstrate the relevancy of the ISCED framework to assess low-skilled workers. Here, their results are extended to medium and high-skilled workers.

[12] EU KLEMS is a project funded by the European Commission's 6th Framework Programme (FP6) whose major output is a database for measuring and analyzing multifactor productivity by industry in EU and selected non-EU countries. One important aspect of measuring productivity is to take account of labour quality hence EU KLEMS provides estimates of labour input by skill levels (www.euklems.net).

ISCO-88 one-digit (Occupation type)	Associated Skills
0 Armed forces	Not included in the analysis
1 Legislators, senior officials, managers	High skilled
2 Professionals	High skilled
3 Technicians and associate professionals	High skilled
4 Clerks	Medium skilled
5 Service workers and shop and market sale workers	Medium skilled
6 Skilled agricultural and fishery workers	Medium skilled
7 Craft and related trade workers	Medium skilled
8 Plant and machine operators and assemblers	Low skilled
9 Elementary occupations	Low skilled

While considering education as a proxy of skills, the following skills associations are established on the basis of the ISCED-97.

ISCED-97 (Educational attainment)	Associated Skills
1 Primary education	Low skilled
2 Lower secondary /second stage of basic education	Low skilled
3 Upper secondary education	Medium skilled
4 Post secondary non-tertiary education	Medium skilled
5 First stage of tertiary education	High skilled
6 Second stage of tertiary education	High skilled

Both of these proxies are assessed on the labour force, and not on the adult population or on students, which fills a gap in current data sets (see Wößmann, 2003 p.248). Resorting to these both proxies would allow undertaking robust cross-country analyses at industry level and testing for robustness of results on each proxy.

By documenting skills upgrading, this article stands along other previous analyzes (Bound and Johnson, 1992; Murphy and Welch, 1992; Katz and Murphy, 1992; Steiner and Mohr, 2000).

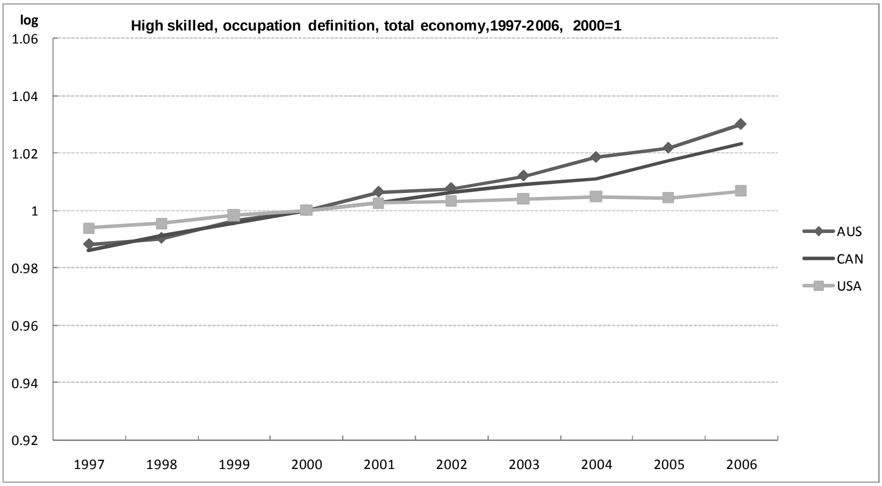
In this study, the variable assessing the labour productivity, as well as the major part of the control variables of come from the OECD's Structural Analysis (STAN) database where a number of variables, such as production, value added, total employment and investment are already available at a relatively detailed level of industry. The recently updated version of the STAN database enables us to carry on this work by leading a panel data analysis over the 1997-2006 period at a 2-digit industry level.

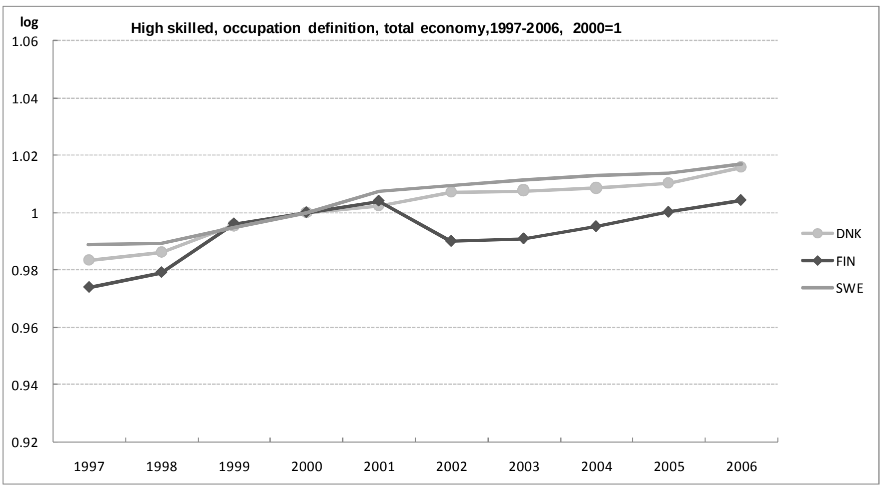
Finally, the control for R&D expenditures is realised thanks to the ANBERD database where data on business expenditures for R&D are available at industry level.

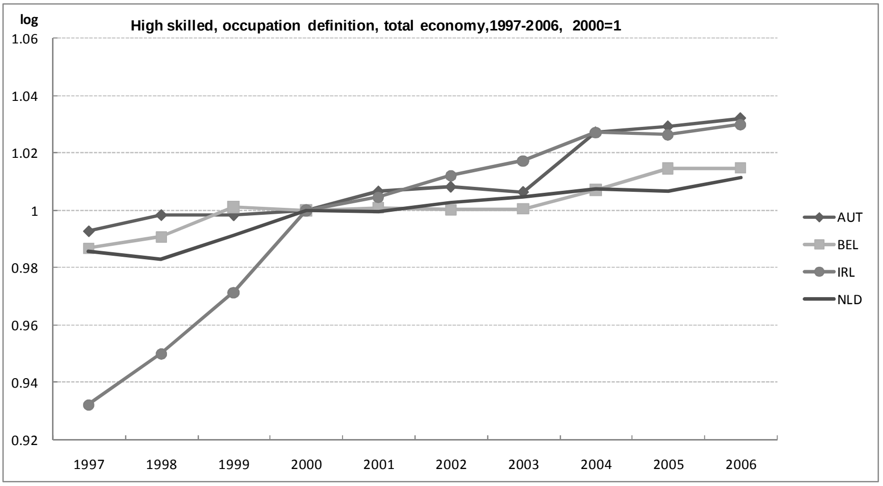
3.2. High skilled workers: occupation and education definitions

Figures 1 and 2 show the evolution of the number of high skilled workers defined with the occupation proxy on the one hand, and with the education proxy on the other hand. In the same manner, Figures 3 and 4 present the evolution of labour productivity assessed with both of the proxies (value added/employment and production/employment ratios). All these figures are plotted on the logarithmic scale and are normalized at 2000=1 in order to ease cross-country comparisons.

Figure 1.
High skilled workers (occupation definition) in OECD countries, 1997-2006






log
High skilled, occupation definition, total economy,1997-2006, 2000=1
1.06
1.04
1.02
1
0.98
0.96
0.94
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1997
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AUT
BEL
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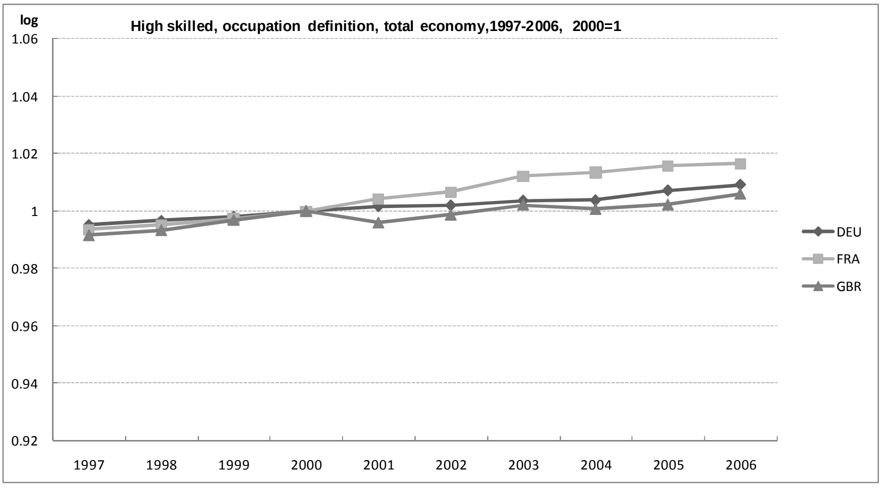
log
High skilled, occupation definition, total economy,1997-2006, 2000=1
1.06
1.04
1.02
1
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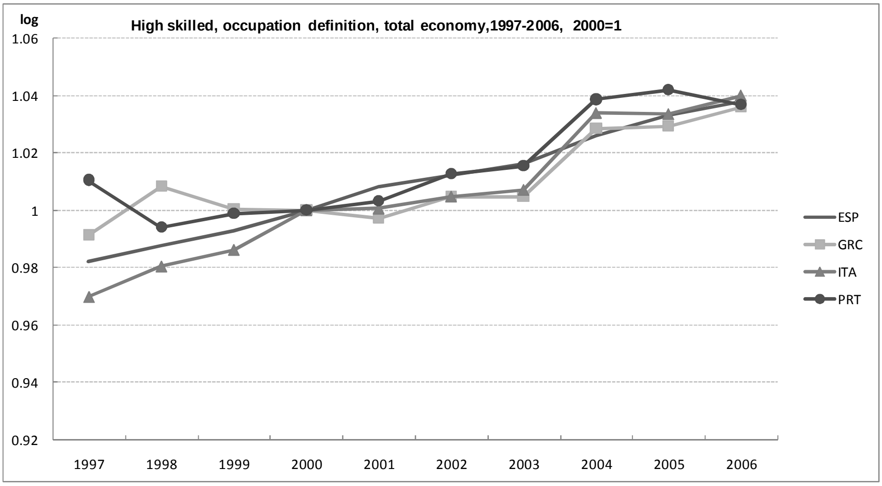


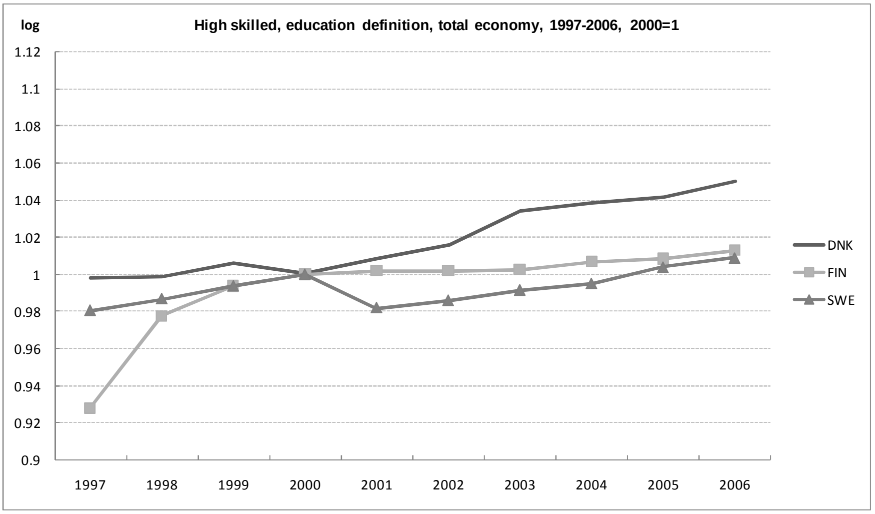
Source. OECD, ANSKILL database (2008).

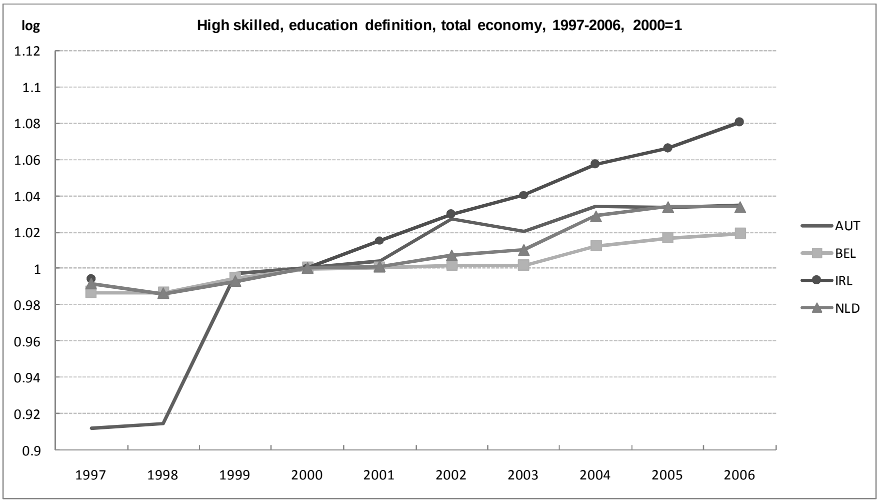
In all countries for which the times series are available, a net increase in the numbers of the high skilled is observed through the 1997-2006 period (Figures 1 and 2). The occupation proxy plots show that the most significant catch-up occurred in Italy and Ireland, whereas the United States, Germany and France experienced a rather flat evolution. The sharp decrease in the numbers of the high skilled workers in Finland in the early 2000’s may be due to the dot-com bubble burst. Finally, the Southern European countries (Spain, Greece, Italy and Portugal) are the ones where growth rates of the high skilled workers (occupation definition) reached the highest levels at the end of the period.

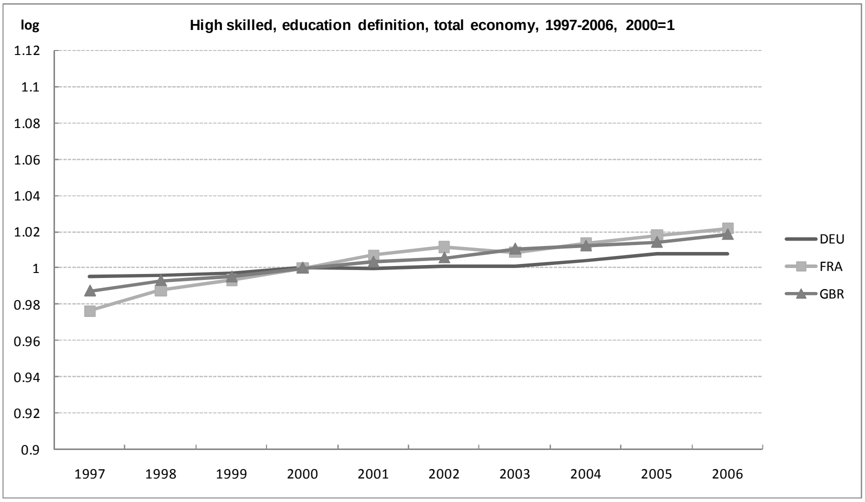
Variations over the (1997-2006) period are more important when skills are assessed with the education proxy (Figure 2) compared to the occupation proxy. Austria and Finland registered the highest growth rates between 1997 and 1999 and from 2000 on, growth rates in high skilled workers were the highest in Portugal and Ireland.

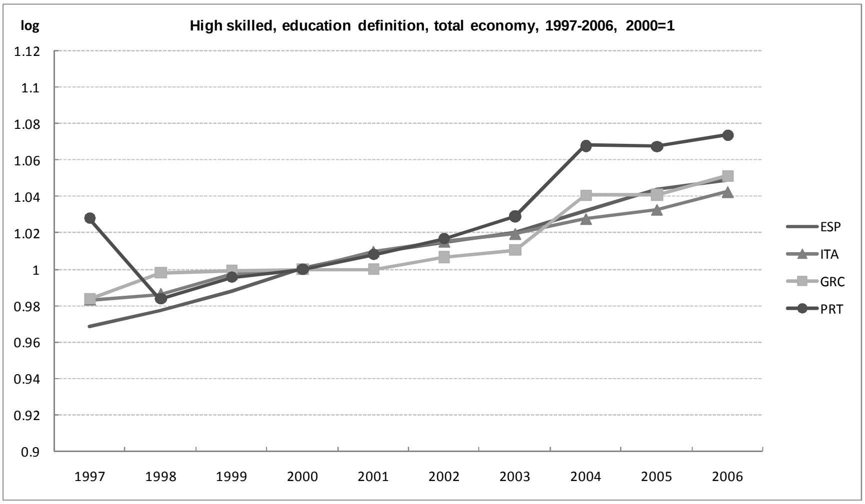
With both proxies Germany, France and the United Kingdom turn out as presenting very similar trends; rather flat plots with least important increases compared to other countries.

Figure 2.
High skilled workers (education definition) in OECD countries, 1997-2006





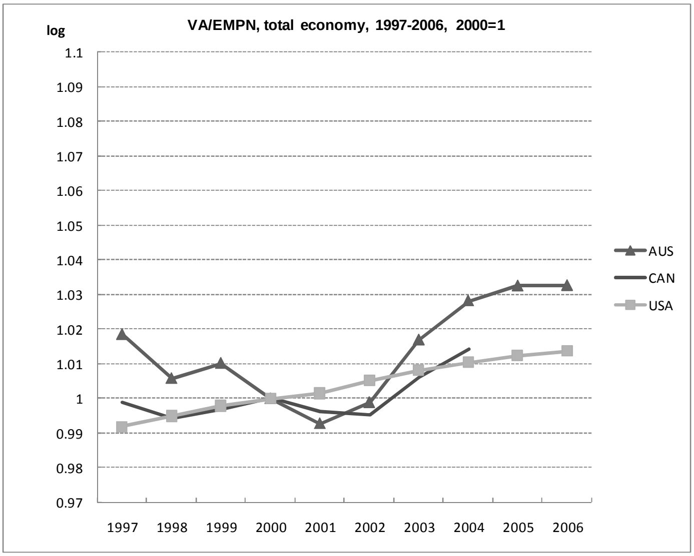


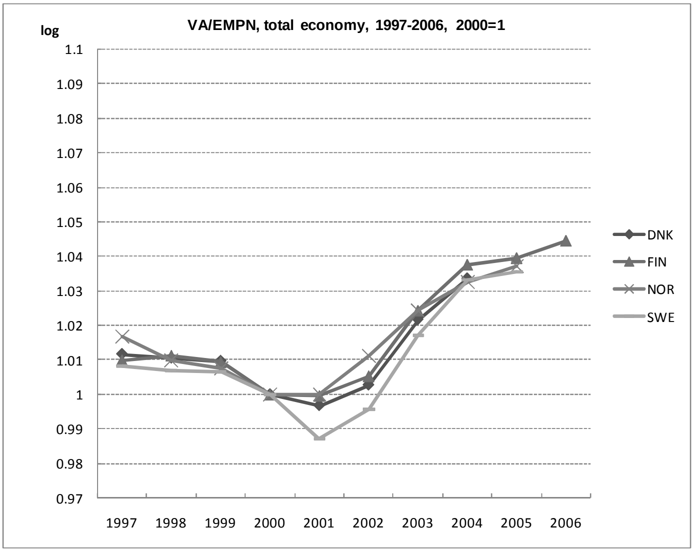


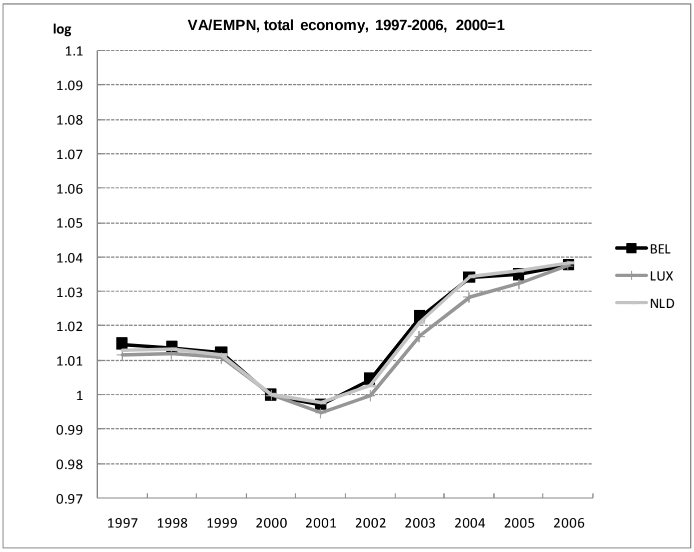
Source. OECD, ANSKILL database (2008).

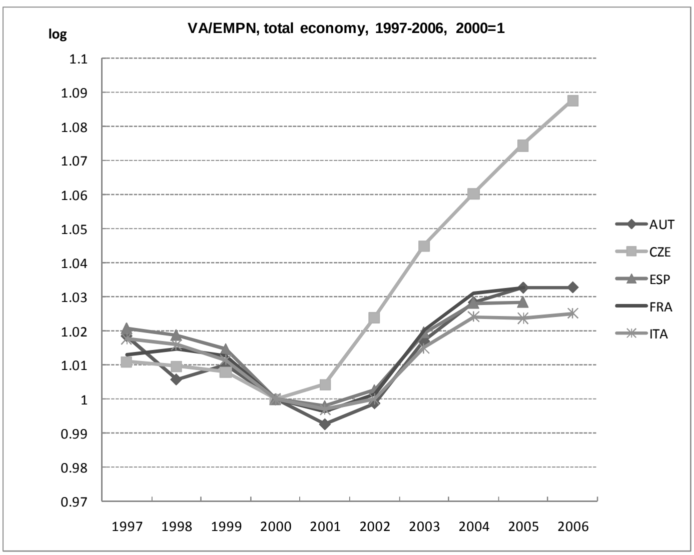
As far as the evolution of the value added/employment ratio is concerned (Figure 3), a general decreasing trend can be noticed from 1997 to 2001 in all countries. However, an important boost seems to take place afterwards, the only exception being the United States where a continuous increase is observed over the period.

Figure 3.
Labour productivity (VA/EMPN) growth in OECD countries, 1997-2006





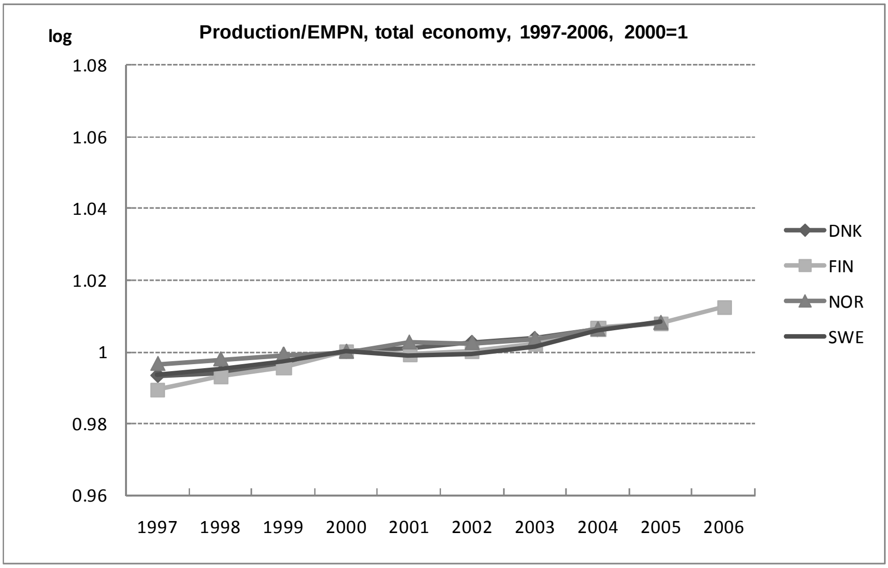


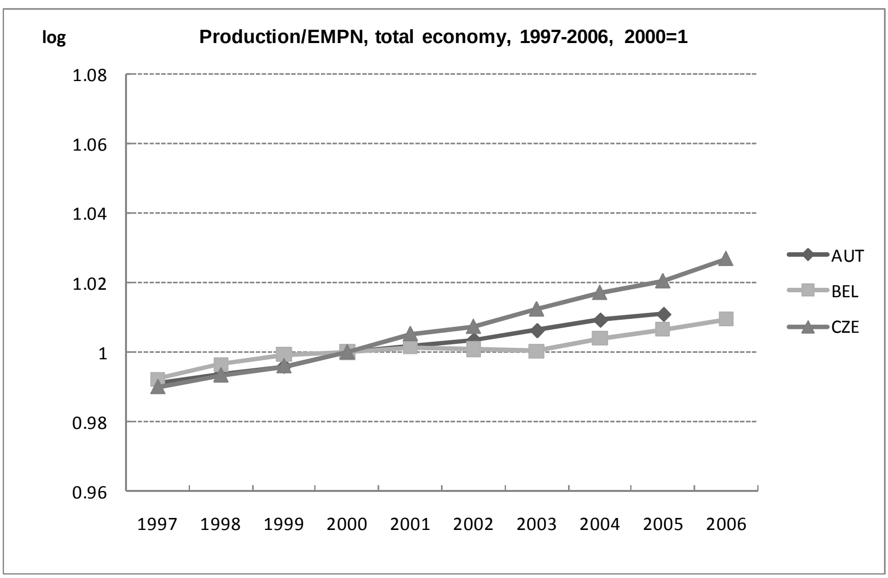


Source. OECD, STAN database (2008).

Trends in the production/employment ratio are also quite similar across countries (Figure 4). A continuous increase over the period is noticed for all countries. The highest rise is registered in the Czech Republic, as it is also the case for the value added/employment ratio.

Figure 4.
Labour productivity (PROD/EMPN) growth in OECD countries, 1997-2006





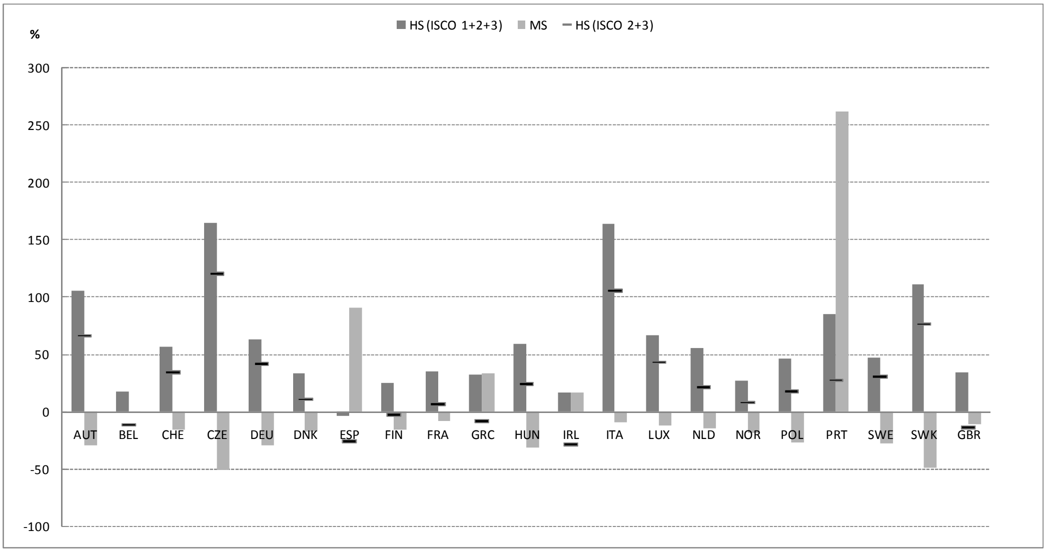
Source. OECD, STAN database (2008).

Another type of comparative analysis of the occupation and the education proxies is presented in Figure 5. For countries for which both of the skill proxies are available, we calculate the following ratio on the basis of the 2006 data:

$$\left(\frac{\text{Number of the HS (occupation definition)}}{\text{Number of the HS (education definition)}} \text{x } 100\right) - 100$$

This indicator is calculated separately for the broad category of the highly skilled (ISCO groups 1+2+3) and for the narrow category of the highly skilled, also known as the HRST (human resources in science and technology) which includes exclusively the ISCO groups 2+3. This latter allows avoiding the definition problems of "managers" (ISCO 1) across countries. Right-hand bars of each country show the same ratio for the medium skilled workers.

Figure 5.
Comparative importance of occupation and educational attainment in skill assessment across countries, 2006



Source. OECD, ANSKILL database (2008).

According to the Figure 5, in Austria, there are two times (100%) more high skilled workers when we use the occupation definition compared to the education definition. This ratio is even higher for countries such as the Czech Republic (164%), Italy (163%) or the Slovak Republic (111%). Ratios are smaller once managers are excluded from the analysis. On the other hand, in all countries except Portugal, Spain, Greece and Ireland, the number of medium skilled workers defined by occupation seem to be lower than the number of the medium skilled workers defined by educational attainment.

3.3 Industry-level focus[13] on the growth of the highly skilled (occupation definition)

In this section, the EU-15 area (Figure 6) is compared with the United States (Figure 7) and Canada (Figure 8) as regards the growth of the high skilled workers in medium-high and high technology industries (ISIC 24, 29t33 and 34t 35[14]) on the one hand[15], and in the knowledge intensive business services (ISIC 64, 65 to 67, 71 to 74) on the other hand[16]. The complete STAN industry list is presented in the annex of this document.

In all countries, the most important increase is observed in business services sectors. In the European Union computer and related activities (ISIC 73) registered an average annual growth rate of 3.3% over the 1997-2006 period. The rate was almost 12% for the broader category of renting and other business activities (ISIC 71t74) in the United States and 6.1% in Canada for the 72t74 ISIC category.

The second highest growth rates are observed in insurance and pension funding sectors (ISIC 67) in the EU-15 area (5.3%) and in financial intermediation related activities (ISIC 65 and 67) in the United States (4.1%).

In Canada, the second most important increase (4.0%) is observed in the machinery and equipment sectors (ISIC 29t33), followed by chemicals and chemical products (ISIC 24).

In parallel, in the United States a strong decrease can be noticed in the number of high skilled workers in the machinery and equipment

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[13] The industry detail level provided here depends on the availability of the data in the ANSKILL database.

[14] Includes shipbuilding.

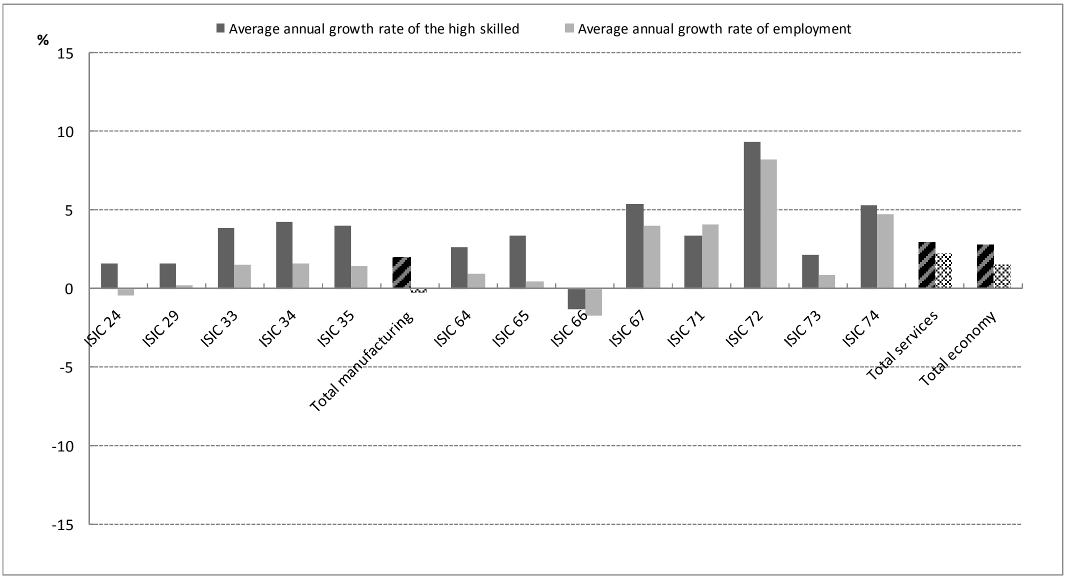
[15] For further reading on classification of economic activities according to their technology intensity, see Hatzichronoglou, T. (1997), "Revision of the High-Technology Sector and Product Classification", *STI Working Paper 1997/2*, OECD, Paris.

[16] For further reading on knowledge intensive business services, see OECD (2006), *Innovation and Knowledge Intensive Service Activities*, Paris.

not elsewhere classified (ISIC 29), in post and telecommunications (ISIC 64) and to a lesser extent, in total manufacturing (ISIC 15t37). In all these sectors, total employment also decreased over the period.

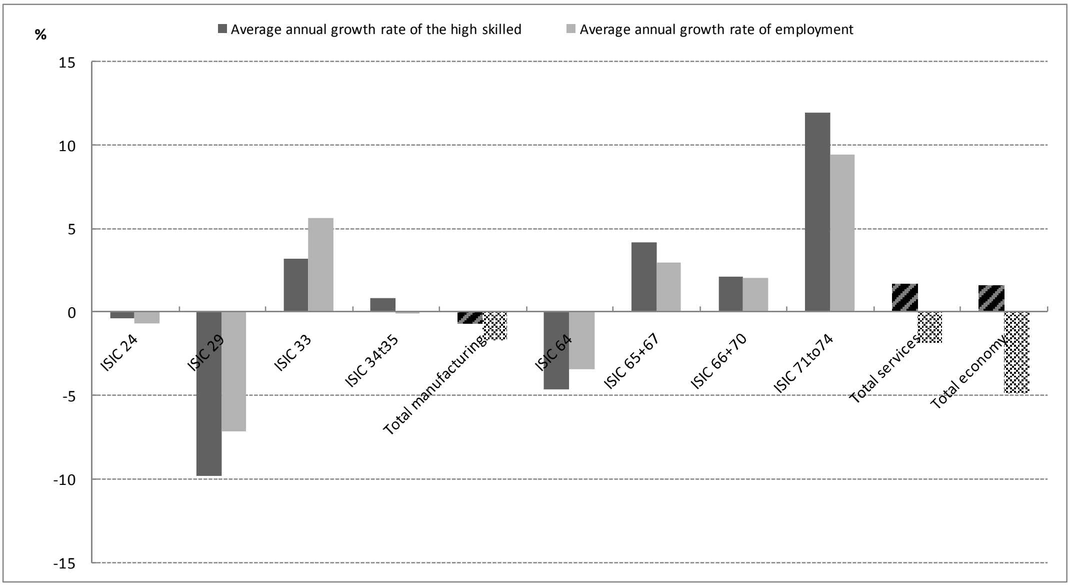
In all countries, increases in the high skilled workers in total economy are driven by increases in the services sectors (ISIC 50 to 99).

Figure 6.
Growth of high skilled workers in the EU-15 area, medium-high and high tech industries and in knowledge intensive business services, (1997-2006)



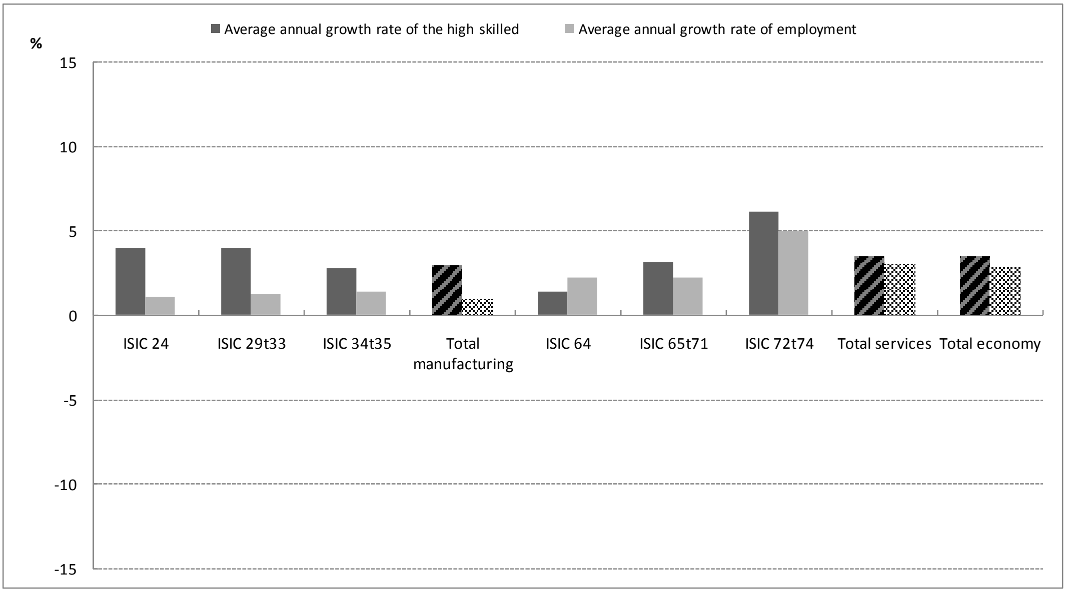
Source. OECD, ANSKILL database (2008).

Figure 7.
Growth of high skilled workers in the United States, medium-high and high technology industries and in knowledge intensive business services, (1997-2006)



Source. OECD, ANSKILL database (2008).

Figure 8.
Growth of high skilled workers in Canada, medium-high and high tech industries and in knowledge intensive business services, (1997-2006)



Source. OECD, ANSKILL database (2008).

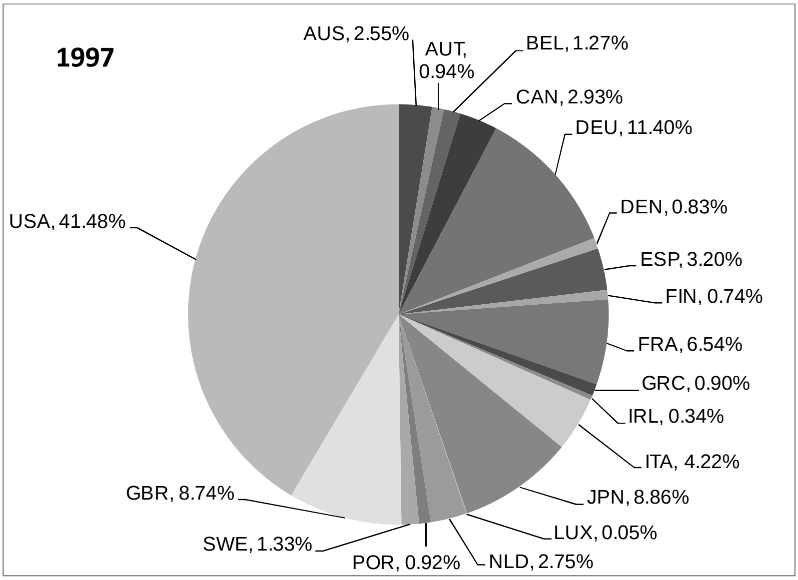
3.4 Country shares in the OECD stock of the high skilled workers (occupation definition)

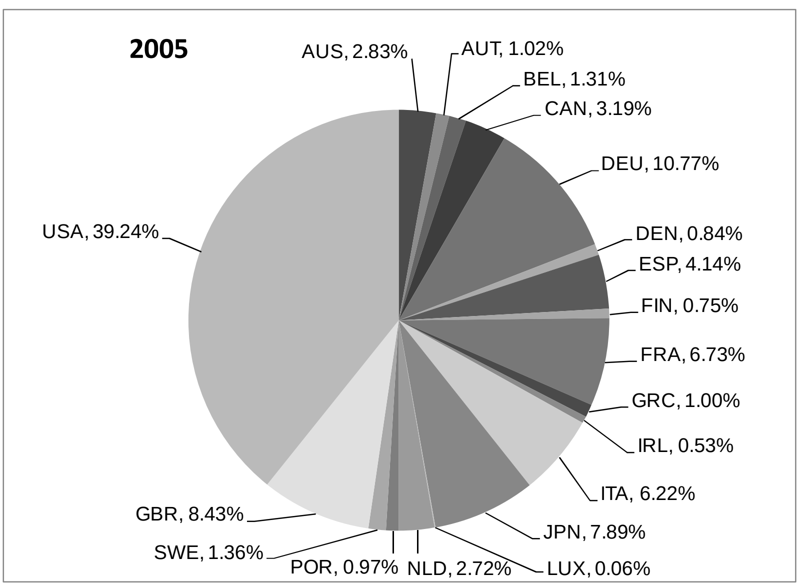
Figure 9 provides information on countries' shares in the stock of the high skilled workers at OECD level. The United States is by far the leader country with around 40% of the total high skilled workers in 2005 in the OECD total. It is followed by Germany (10.7%) and the United Kingdom (8.4%).

As far as the medium-high and high technology industries are concerned (Table 1), Japan takes the third place with 10% of the high-skilled workers stock in OECD countries. In parallel, the share of the high skilled workers in the United States and, in a lesser extent, in the United Kingdom decreased considerably between 1997 and 2005.

Another focus on the knowledge intensive business services (Table 2) shows that Spain and Italy gained in terms of the high skilled workers' stock passing from 3.3 to 4.0% and from 5.5 to 6.5%, respectively. On the other hand, from 1997 to 2005 the United Kingdom, Germany and France experienced a decrease in their share of high skilled workers over the OECD total in knowledge intensive business services.

Figure 9.
High skilled workers stock in OECD countries, total economy, 1997 and 2005





Source. OECD, ANSKILL database (2008).

Table 1.
High skilled workers stock in OECD countries, medium-high and high technology industries, (2005)

	1997	%	2005	%
AUS	N/A	N/A	N/A	N/A
AUT	67.7	0.91	97.6	1.22
BEL	95.0	1.28	109.3	1.37
CAN	127.5	1.71	162.7	2.04
DEU	1400.8	18.80	1435.3	17.96
DEN	52.7	0.71	69.6	0.87
ESP	191.7	2.57	265.7	3.32
FIN	61.5	0.83	84.1	1.05
FRA	618.2	8.30	704.4	8.81
GRC	18.9	0.25	23.4	0.29
IRL	31.9	0.43	45.7	0.57
ITA	304.7	4.09	538.5	6.74
JPN (1)	N/A	N/A	800.0	10.01
LUX	1.0	0.01	0.7	0.01
NLD	142.4	1.91	117.9	1.48
POR	34.8	0.47	43.4	0.54
SWE	128.1	1.72	114.2	1.43
GBR	764.1	10.26	700.9	8.77
USA	3409.0	45.76	2679.0	33.52
TOTAL	**7449.8**	**100**	**7992.5**	**100**

Source. OECD, ANSKILL database (2008).

Table 2.
High skilled workers stock in OECD countries, knowledge intensive business services, (2005)

	1997	**%**	**2005**	**%**
AUS	N/A	N/A	N/A	N/A
AUT	139.5	0.82	262.6	0.92
BEL	230.4	1.35	313.9	1.11
CAN (2)	847.3	4.96	1158.0	4.08
DEU	1942.7	11.37	2672.4	9.41
DEN	195.6	1.14	258.4	0.91
ESP	577.2	3.38	1147.3	4.04
FIN	130.1	0.76	201.0	0.71
FRA	1464.8	8.57	1981.1	6.98
GRC	159.4	0.93	264.0	0.93
IRL	66.9	0.39	148.7	0.52
ITA	942.0	5.51	1855.5	6.53
JPN (1)	N/A	N/A	2350.0	8.27
LUX	17.1	0.10	26.1	0.09
NLD	610.4	3.57	788.1	2.78
POR	194.0	1.14	208.0	0.73
SWE	323.9	1.90	459.1	1.62
GBR	2058.4	12.04	2623.0	9.24
USA (2)	7190.0	42.07	11683.0	41.14
TOTAL	**17089.6**	**100**	**28400.2**	**100**

(1): data for 1997 and 2004
(2): figures include real estate activities
Unit: (000)
Source. OECD, ANSKILL database (2008).

4 Empirical analysis

4.1 Definition of variables and the empirical specification

On the basis of the existing economic literature presented above, in order to investigate the relations between skills and labour productivity, we measure the following equations.

(1) $$\mathit{log}\text{VA/Empe}_{i,c,t} = {}_{0} + {}_{1}.\text{HSocc/Empe}_{i,c,t} + {}_{2}.\text{MSocc/Empe}_{i,c,t} + {}_{3}\mathit{log}\text{GKStock/Empe}_{i,c,t} + {}_{4}.\mathit{log}\text{RD}_{i,c,t} + {}_{5.}\mathit{log}\text{Expo/Impo}_{i,c,t} + \varepsilon_{i,c,t}$$

(2) $$\mathit{log}\text{VA/Empe}_{i,c,t} = {}_{0} + {}_{1}.\text{HSedu/Empe}_{i,c,t} + {}_{2}.\text{MSedu/Empe}_{i,c,t} + {}_{3}\mathit{log}\text{GKStock/Empe}_{i,c,t} + {}_{4}.\mathit{log}\text{RD}_{i,c,t} + {}_{5}.\mathit{log}\text{Expo/Impo}_{i,c,t} + \varepsilon_{i,c,t}$$

(3) $$\mathit{log}\text{PROD/Empe}_{i,c,t} = {}_{0} + {}_{1}.\text{HSocc/Empe}_{i,c,t} + {}_{2}.\text{MSocc/Empe}_{i,c,t} + {}_{3}\mathit{log}\text{GKStock/Empe}_{i,c,t} + {}_{4}.\mathit{log}\text{RD}_{i,c,t} + {}_{5}.\mathit{log}\text{Expo/Impo}_{i,c,t} + \varepsilon_{i,c,t}$$

(4) $$\mathit{log}\text{PROD/Empe}_{i,c,t} = {}_{0} + {}_{1}.\text{HSedu/Empe}_{i,c,t} + {}_{2}.\text{MSedu/Empe}_{i,c,t} + {}_{3}\mathit{log}\text{GKStock/Empe}_{i,c,t} + {}_{4}.\mathit{log}\text{RD}_{i,c,t} + {}_{5}.\mathit{log}\text{Expo/Impo}_{i,c,t} + \varepsilon_{i,c,t}$$

Where *c* represents country at time *t* in a given industry i. $\varepsilon_{i,c,t}$ is a normally error term.

In line with the OECD Manual on Measuring Productivity (2001b), the dependent variable, labour productivity is assessed in two ways: value added/employment ratio as shown in the equations (1) and (2) on the one hand, and production/employment ratio as shown in the equations (3) and (4).

The explanatory variable, workers' skills are also measured in two ways: The equations (1) and (3) consider the occupation of individuals as a proxy of their skill level, whereas the equations (2) and (4) take into account their educational attainment.

4.2 Econometric tests

Descriptive statistics and definitions of the variables included in the econometric analysis are shown in the table 3.

Table3
Descriptive statistics

Variable	Definition	Obs	Mean	Std. Dev.	Min	Max
HISE	Number of high skilled workers, education proxy	12412	0.22211	0.1606935	0.0010219	0.91309
MESE	Number of medium skilled workers, education proxy	12412	0.4645854	0.1778491	0.0060569	0.94969
HISO	Number of high skilled workers, occupation proxy	12815	0.3350589	0.196289	0.0008245	0.96573
MESO	Number of medium skilled workers, occupation proxy	12815	0.4171283	0.1871642	0.0107126	0.98195
VA/EMPE	Value added in constant prices, $ / Full-time equivalent total	19885	11.06301	0.9522414	5.34173	17.5797
PROD/EMPE	Production in constant prices, $ / Full-time	27164	21.91115	3.388715	6.838407	30.8344
GFCF/EMPE	Gross fixed capital formation, in constant prices, $ /	12962	10.2431	1.863587	4.456433	19.0667
R&D	Business expenditures on R&D, ppp $	15222	18.22193	2.712146	2.408803	26.2367
EXPO/IMPO	Exports / Imports, in constant prices, $	19675	-0.53443	-1.669316	18.50929	10.866

In order to determine the relevancy of both of the skill proxies and to assess the impact of the high skilled workers on labour productivity, a panel data analysis is conducted over the 1997-2006 period. To start, the Hausman test has been performed and allowed us to use the fixed effect model. Fixed effects control for any idiosyncratic characteristic of the countries and of industries that may explain differences in skills and productivity indicators.

As for the general comments on these estimations, one can immediately notice that as soon as the skill proxy is significant, its coefficient is positive. This means that the more the skill share of employment is high the more it has an impact on labour productivity.

Not surprisingly, another general result is the strong coefficient of the capital stocks. The capital intensity of industries has a positive and significant effect on labour productivity measured by value added or production. This observation is also valid for the business R&D expenditures indicating firms’ innovative performance.

The predictive capacity of the models increases while introducing new variables into the equations but the R-squared remains around

20% throughout the models. In addition, there is an important decrease in the number of observations, which is mainly due to the industry and country coverage of the data on capital stocks, on exports/imports and the time and industry coverage of the business expenditures on R&D data.

Estimation results for the equations (1) and (2) are shown in tables 4 and 5 where the impact of the high skilled on labour productivity is positive and significant with both of the proxies (occupation of individuals and their educational attainment). On the other hand, medium skilled variable provides positive and significant coefficients with the education proxy exclusively.

The introduction of capital and R&D control variables does not affect the initial findings however, the export/import ratio (which is an indicator of trade performance of industries) does not seem to have an impact on the labour productivity in OECD countries over the 1997-2006 period.

Table 4
Labour productivity (VA/Employment) estimation results with the occupation proxy

	model1	model2	model3	model4	model5
	b/t	b/t	b/t	b/t	b/t
hiso_share	**0.783*****	**0.592*****	**0.883*****	**1.261*****	**1.364*****
	(9.838)	(6.323)	(7.352)	(9.137)	(9.041)
meso_share		-0.289***	-0.160	-0.132	-0.093
		(-4.009)	(-1.536)	(-1.091)	(-0.751)
lgfck_empe			0.165***	0.117***	0.086*
			(4.120)	(3.458)	(2.288)
lrdnc_ppp				0.067***	0.069**
				(4.893)	(3.089)
lexpo_us_impo_us					0.006
					(0.441)
_cons	10.848***	11.034***	9.217***	8.307***	8.554***
	(406.864)	(203.752)	(22.338)	(21.540)	(17.525)
r2	0.035	0.039	0.081	0.134	0.131
N	10315	10315	7063	4003	2918

Note: Number in parentheses are t-statistics.
* significant at 5%, ** significant at 1%, *** significant at 1‰.

Table 5
Labour productivity (VA/ Employment) estimation results with the education proxy

	model6	model7	model8	model9	model10
	b/t	b/t	b/t	b/t	b/t
hise_share	**1.392*****	**1.797*****	**2.397*****	**2.578*****	**2.355*****
	(11.440)	(15.132)	(16.437)	(15.277)	(12.576)
mese_share		0.749***	1.391***	1.686***	1.586***
		(9.529)	(12.486)	(13.236)	(10.536)
lgfck_empe			0.150***	0.110**	0.086*
			(4.112)	(3.226)	(2.179)
lrdnc_ppp				0.040**	0.046*
				(3.205)	(2.122)
lexpo_us_impo_us					0.007
					(0.559)
_cons	10.811***	10.369***	8.413***	7.902***	8.141***
	(401.798)	(209.389)	(23.493)	(21.301)	(16.455)
r2	0.072	0.100	0.186	0.253	0.224
N	10010	10010	6931	3948	2794

Note: Number in parentheses are t-statistics.
* significant at 5%, ** significant at 1%, *** significant at 1‰.

In the same way, while labour productivity is proxied by the production/employment ratio (equations 3 and 4), the high skilled share of employment has a positive a significant with either of the two skill proxies (tables 6 and 7).

Table 6
Labour productivity (Production/Employment) estimation results with the occupation proxy

	model11	model12	model13	model14	model15
	b/t	b/t	b/t	b/t	b/t
hiso_share	**1.048*****	**0.748*****	**1.267*****	**1.794*****	**1.782*****
	(10.674)	(6.521)	(7.179)	(9.568)	(9.047)
meso_share		-0.467***	-0.442**	-0.285	-0.198
		(-4.906)	(-2.738)	(-1.580)	(-1.084)
lgfck_empe			0.179***	0.114**	0.054
			(5.421)	(2.787)	(1.306)
lrdnc_ppp				0.128***	0.127***
				(5.667)	(4.210)
lexpo_us_impo_us					0.021
					(1.611)
_cons	22.596***	22.893***	21.246***	19.628***	19.864***
	(684.242)	(331.947)	(62.724)	(35.989)	(30.503)
r2	0.032	0.037	0.073	0.139	0.125
N	11461	11461	6719	3780	2773

Note: Number in parentheses are t-statistics.
* significant at 5%, ** significant at 1%, *** significant at 1‰.

Table 7
Labour productivity (Production/ Employment) estimation results with the <u>education proxy</u>

	model16	model17	model18	model19	model20
	b/t	b/t	b/t	b/t	b/t
hise_share	**1.866*** **	**2.483*** **	**3.567*** **	**3.594*** **	**3.047*** **
	(13.106)	(16.653)	(16.559)	(12.932)	(10.422)
mese_share		1.121***	2.087***	2.464***	2.213***
		(11.324)	(11.720)	(12.388)	(10.311)
lgfck_empe			0.168***	0.118**	0.065
			(5.319)	(2.804)	(1.431)
lrdnc_ppp				0.094***	0.096***
				(4.607)	(3.339)
lexpo_us_impo_us					0.021*
					(2.042)
_cons	22.587***	21.922***	19.833***	18.781***	19.113***
	(730.800)	(330.271)	(61.554)	(38.026)	(30.984)
r2	0.065	0.096	0.167	0.229	0.196
N	11176	11176	6618	3746	2668

Note: Number in parentheses are t-statistics.
* significant at 5%, ** significant at 1%, *** significant at 1‰.

The impact of the medium skilled measured by occupation seems to disappear when the models are controls for all other variables. If the capital stocks and R&D variables behave in the same direction as previously, trade performance indicator (exports/imports) becomes positive and significant while explaining the production/employment ratio by the education proxy (table 7). This result needs to be analysed in the further steps of this study.

Finally, the correlation table is provided below for information.

Table 8
Correlation table

	HISE	MESE	HISO	MESO	VA/EMPE	PROD/EMPE	GFCF/EMPE	R&D	EXPO/IMPO
HISE	1								
MESE	-0.2029	1							
HISO	0.7947	0.0763	1						
MESO	-0.4817	0.0248	-0.5848	1					
VA/EMPE	0.4883	0.0479	0.4971	-0.3385	1				
PROD/EMPE	0.1584	-0.3331	0.0838	0.0079	0.3613	1			
GFCF/EMPE	0.0568	0.3987	0.1741	-0.1984	0.1053	-0.5105	1		
R&D	0.324	-0.0244	0.3232	-0.1803	0.2792	0.7067	-0.1199	1	
EXPO/IMPO	0.0112	0.0001	0.051	-0.1077	0.0363	0.1765	-0.0067	0.2357	1

5 Conclusion

This study provides important insights with respect to the role of skills in explaining labour productivity across OECD countries over the 1997-2006 period. Empirical estimations showed that occupation and education turn out as presenting similar impacts on labour productivity. Their associated coefficients have similar values with significant coefficients. When the models are controlled for capital stocks, innovation efforts or trade performance, results remain unchanged regarding the skill composition of employment.

However, these empirical estimations need to be developed more in-depth so as to take into account sectoral differences across countries. Indeed, the skill pattern of one specific sector may different whether the proxy used is workers' *educational attainment* or *occupation type*. As suggested by Acha and Von Tunzelmann (2004), this evidence would lead to reconsider the current OECD classification of industries according to their technology intensity by taking into account their knowledge intensity as well.

In a policy perspective, these results confirm the important role of the investments in skills in order to promote and sustain economic growth. Indeed, many OECD countries have already entered in a phase of increasing as much as possible, the share of the high skilled individuals within the total employment. This is mainly observed by the strong increases in the educational attainment of the population. In addition, over the recent years, OECD countries oriented their immigration policies towards a more skilled-biased basis.

Nevertheless, before addressing general policy recommendations, one should take into account all the possible country and industry specifications before putting in place any specific employment policy such as the vocational training programs or *numerus clausus* types of regulations of professions. Therefore, one of the main items on our further research agenda is the emphasis on the country-specific impacts of skills on labour productivity in order to enable member countries set up appropriate employment policies.

In the same way, another research question could be the identification of a threshold, for the increasing skill acquisition in countries, above which labour productivity would no longer be in an increasing phase even though the increasing skill acquisition phenomena. Such an indicator may allow sound industrial policies that could engage may industries in a more competitive and innovative position worldwide.

Last but not least, as soon as the ANSKILL database includes a variable on earnings by industry and by skill levels for all countries, further studies could be conducted on investigating the reasons of the increasing phenomena of skill acquisition, explaining the skill premium differentials across countries or the overall impact of skills on the economic performance of industries.

Annex

Stan industry list

STAN industry list

Description	ISIC Rev.3
TOTAL	**01-99**
AGRICULTURE, HUNTING, FORESTRY AND FISHING	**01-05**
AGRICULTURE, HUNTING AND FORESTRY	**01-02**
….AGRICULTURE, HUNTING AND RELATED SERVICE ACTIVITIES	01
….FORESTRY, LOGGING AND RELATED SERVICE ACTIVITIES	02
FISHING, FISH HATCHERIES, FISH FARMS AND RELATED SERVICES	**05**
INDUSTRY INCLUDING ENERGY	**10-41**
MANUFACTURING	**15-37**
FOOD PRODUCTS, BEVERAGES AND TOBACCO	15-16
….FOOD PRODUCTS AND BEVERAGES	15
….TOBACCO PRODUCTS	16
TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR	17-19
….TEXTILES AND TEXTILE PRODUCTS	17-18
……..TEXTILES	17
……..WEARING APPAREL, DRESSING AND DYEING OF FUR	18
….LEATHER, LEATHER PRODUCTS AND FOOTWEAR	19
WOOD AND PRODUCTS OF WOOD AND CORK	20
PULP, PAPER, PAPER PRODUCTS, PRINTING AND PUBLISHING	21-22
….PULP, PAPER AND PAPER PRODUCTS	21
….PRINTING AND PUBLISHING	22
CHEMICAL, RUBBER, PLASTICS AND FUEL PRODUCTS	23-25
….COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL	23
….CHEMICALS AND CHEMICAL PRODUCTS	24
……..CHEMICALS EXCLUDING PHARMACEUTICALS	24 *less* 2423
……..PHARMACEUTICALS	2423
….RUBBER AND PLASTICS PRODUCTS	25
OTHER NON-METALLIC MINERAL PRODUCTS	26
BASIC METALS, METAL PRODUCTS, MACHINERY AND EQUIPMENT	27-35
BASIC METALS AND FABRICATED METAL PRODUCTS	27-28
….BASIC METALS	27
……..IRON AND STEEL	271+2731
……..NON-FERROUS METALS	272+2732
….FABRICATED METAL PRODUCTS, except machinery and equipment	28
MACHINERY AND EQUIPMENT	29-33
….MACHINERY AND EQUIPMENT, N.E.C.	29
….ELECTRICAL AND OPTICAL EQUIPMENT	30-33
……..OFFICE, ACCOUNTING AND COMPUTING MACHINERY	30
……..ELECTRICAL MACHINERY AND APPARATUS, NEC	31
……..RADIO, TELEVISION AND COMMUNICATION EQUIPMENT	32
……..MEDICAL, PRECISION AND OPTICAL INSTRUMENTS	33
TRANSPORT EQUIPMENT	34-35
….MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS	34
….OTHER TRANSPORT EQUIPMENT	35
……..BUILDING AND REPAIRING OF SHIPS AND BOATS	351
……..AIRCRAFT AND SPACECRAFT	353
……..RAILROAD EQUIPMENT AND TRANSPORT EQUIPMENT N.E.C.	352+359
MANUFACTURING N.E.C. AND RECYCLING	36-37
MANUFACTURING N.E.C.	36
RECYCLING	37
HIGH-TECHNOLOGY MANUFACTURES	2423,30,32,33,353
MEDIUM-HIGH TECHNOLOGY MANUFACTURES	24 less 2423,29,31,34,352+359
MEDIUM-LOW TECHNOLOGY MANUFACTURES	23,25-28,351
LOW TECHNOLOGY MANUFACTURES	15-22,36-37
HIGH AND MEDIUM-HIGH TECHNOLOGY MANUFACTURES (incl. 351)	24, 29-35
ENERGY PRODUCING ACTIVITIES	10-12,23,40

Description	ISIC Rev.3
MINING AND QUARRYING	**10-14**
MINING AND QUARRYING OF ENERGY PRODUCING MATERIALS	10-12
….MINING OF COAL AND LIGNITE, EXTRACTION OF PEAT	10
….EXTRACTION OF CRUDE PETROLEUM AND NATURAL GAS AND RELATED SERVICES	11
….MINING OF URANIUM AND THORIUM ORES	12
MINING AND QUARRYING EXCEPT ENERGY PRODUCING MATERIALS	13-14
….MINING OF METAL ORES	13
….OTHER MINING AND QUARRYING	14
ELECTRICITY, GAS AND WATER SUPPLY	**40-41**
….ELECTRICITY, GAS, STEAM AND HOT WATER SUPPLY	40
….COLLECTION, PURIFICATION AND DISTRIBUTION OF WATER	41
CONSTRUCTION	**45**
WHOLESALE AND RETAIL TRADE - RESTAURANTS AND HOTELS	**50-55**
WHOLESALE AND RETAIL TRADE - REPAIRS	50-52
….SALE, MAINTENANCE AND REPAIR OF MOTOR VEHICLES AND MOTORCYCLES - RETAIL SALE OF AUTOMOTIVE FUEL	50
….WHOLESALE, TRADE AND COMMISSION EXCL. MOTOR VEHICLES	51
….RETAIL TRADE EXCL. MOTOR VEHICLES - REPAIR OF HOUSEHOLD GOODS	52
HOTELS AND RESTAURANTS	55
TRANSPORT, STORAGE AND COMMUNICATIONS	**60-64**
TRANSPORT AND STORAGE	60-63
….LAND TRANSPORT - TRANSPORT VIA PIPELINES	60
….WATER TRANSPORT	61
….AIR TRANSPORT	62
….SUPPORTING AND AUXILIARY TRANSPORT ACTIVITIES	63
POST AND TELECOMMUNICATIONS	64
FINANCE, INSURANCE, REAL ESTATE AND BUSINESS SERVICES	**65-74**
FINANCIAL INTERMEDIATION	65-67
....FINANCIAL INTERMEDIATION except insurance and pension funding	65
....INSURANCE AND PENSION FUNDING, except compulsory social security	66
....ACTIVITIES RELATED TO FINANCIAL INTERMEDIATION	67
REAL ESTATE, RENTING AND BUSINESS ACTIVITIES	70-74
....REAL ESTATE ACTIVITIES	70
....RENTING OF MACH. AND EQUIP. - OTHER BUSINESS ACTIVITIES	71-74
……..RENTING OF MACHINERY AND EQUIPMENT	71
……..COMPUTER AND RELATED ACTIVITIES	72
……..RESEARCH AND DEVELOPMENT	73
……..OTHER BUSINESS ACTIVITIES	74
COMMUNITY, SOCIAL AND PERSONAL SERVICES	**75-99**
PUBLIC ADMIN. AND DEFENCE - COMPULSORY SOCIAL SECURITY	75
EDUCATION	80
HEALTH AND SOCIAL WORK	85
OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	90-93
….SEWAGE AND REFUSE DISPOSAL, SANITATION AND SIMILAR ACTIVITIES	90
….ACTIVITIES OF MEMBERSHIP ORGANIZATIONS N.E.C.	91
….RECREATIONAL, CULTURAL AND SPORTING ACTIVITIES	92
….OTHER SERVICE ACTIVITIES	93
PRIVATE HOUSEHOLDS WITH EMPLOYED PERSONS	95
EXTRA-TERRITORIAL ORGANIZATIONS AND BODIES	99
TOTAL SERVICES	**50-99**
BUSINESS SECTOR SERVICES	**50-74**
NON-AGRICULTURE BUSINESS SECTOR excluding Real Estate	**10-67,71-74**
BUSINESS SECTOR SERVICES excluding Real Estate	**50-67,71-74**

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OECD information technology outlook 2010 overview

Graham Vickery[17]

The ICT sector is recovering from the economic crisis and global ICT markets are shifting to non-OECD economies

Prospects for the ICT sector improved rapidly after the crisis and it is expected to grow in OECD countries by 3-4% in 2010

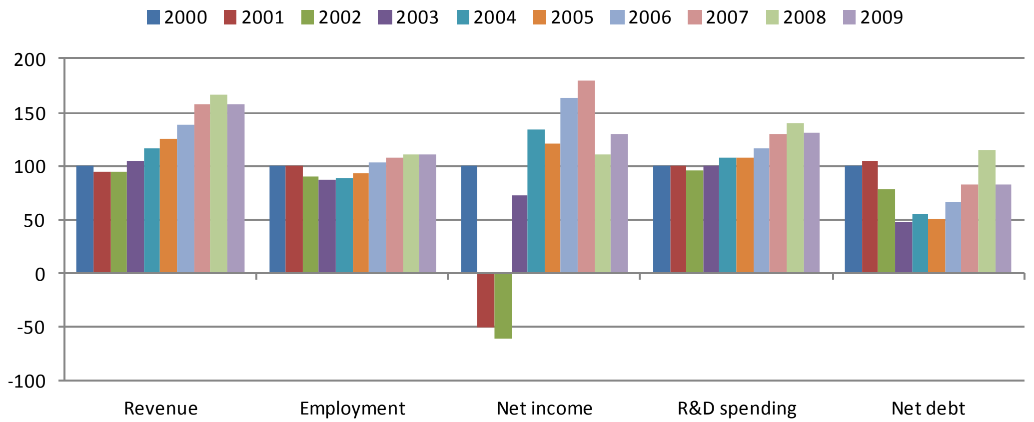
The outlook for ICT production and markets is brighter than in the past two years. The macroeconomic situation has improved since mid-2009, although recovery in OECD countries is slow and uneven and the outlook remains cloudy, particularly due to government debt and financial market instability. Previously very gloomy projections for the ICT sector and for the world macroeconomy have been successively revised upwards since the gloom in the depths of the recession.

ICT growth in OECD countries was down by over 6% in 2009 owing to faltering macroeconomic conditions and poor business and consumer sentiment, but should reach 3-4% in 2010 and even higher in 2011. World ICT spending fell by 4% in 2009 but was expected to grow by some 6% in 2010 with non-OECD economies growing much faster than OECD countries.

[17] Former Head, Information Economy Group, Organisation for Economic Cooperation and Development, Paris. This summary is drawn from the longer publication of the *OECD Information Technology Outlook 2010*, written in conjunction with Cristina Serra Vallejo, Arthur Mickoleit, Christian Reimsbach Kounatze and Verena Weber, OECD, and available at www.oecd.org/sti/ito,

Top 250 ICT firms' average performance trends, 2000-09

Average number of employees and current USD, index 2000=100



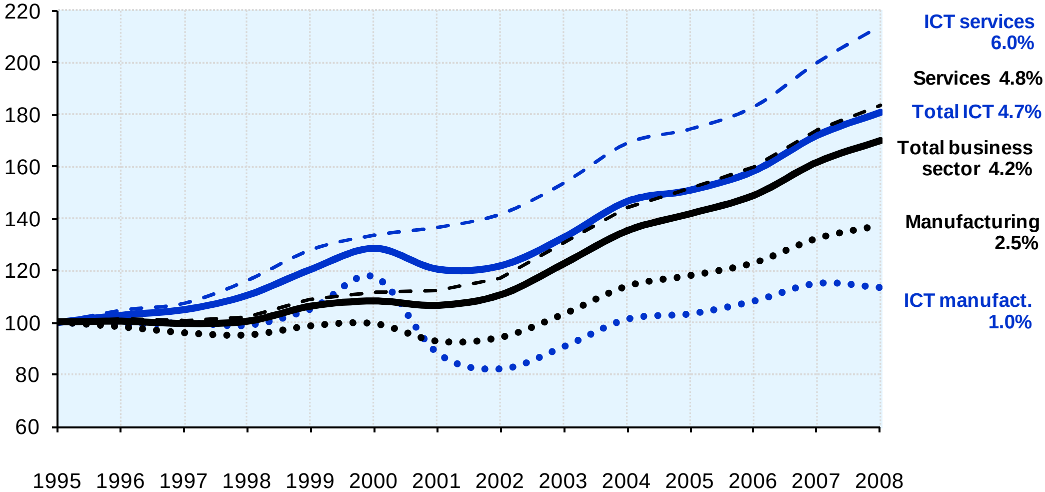
Note: Averages for firms reporting.
Source: OECD, Information Technology Database.

The OECD ICT sector accounts for 8% of business value added and countries with significant ICT manufacturing have comparative advantages in trade

Over the long term, the OECD ICT sector has seen consistent relatively high growth. In 2008 it represented more than 8% of OECD business value added and employed almost 16 million people. With the global restructuring of production, OECD ICT manufacturing has declined, but countries with strong ICT manufacturing value added have maintained their comparative advantage and export surpluses in ICT goods. In 2008, the eleven OECD countries with the largest shares of ICT manufacturing value added in total value added were Korea, Finland, Ireland, Japan, Hungary, Sweden, the Slovak Republic, Germany, the Czech Republic, the United States and Mexico. Of these, ten had a revealed comparative advantage in ICT goods exports and nine had export surpluses.

Growth of ICT sector and total value added in the OECD area, 1995-2008

1995=100, compound annual growth rate in current exchange rates, percentages



Source: OECD, based on national sources, STAN and National Accounts databases, current exchange rates. February 2010.

ICT sector performance differs by segment and country as ICT production and markets shift to non-OECD economies

As ICT manufacturing has shifted to lower-cost locations in OECD countries and Asian economies, the composition of the OECD-area ICT sector has shifted to computer and related services and other ICT services. These services account for more than two-thirds of total ICT sector value added in most countries, their share has increased and they have grown more rapidly than total business services.

In 2009 OECD countries' share of the ICT world market declined to 76% (from 84% in 2003), as growth in non-OECD economies decoupled from growth in OECD countries. As part of this shift the top 250 ICT firms include more non-OECD firms, among them manufacturing firms in Chinese Taipei, which have partly driven the rise of China as the major exporter of ICT goods, IT services firms from India, and telecommunication services providers from a range of non-OECD economies.

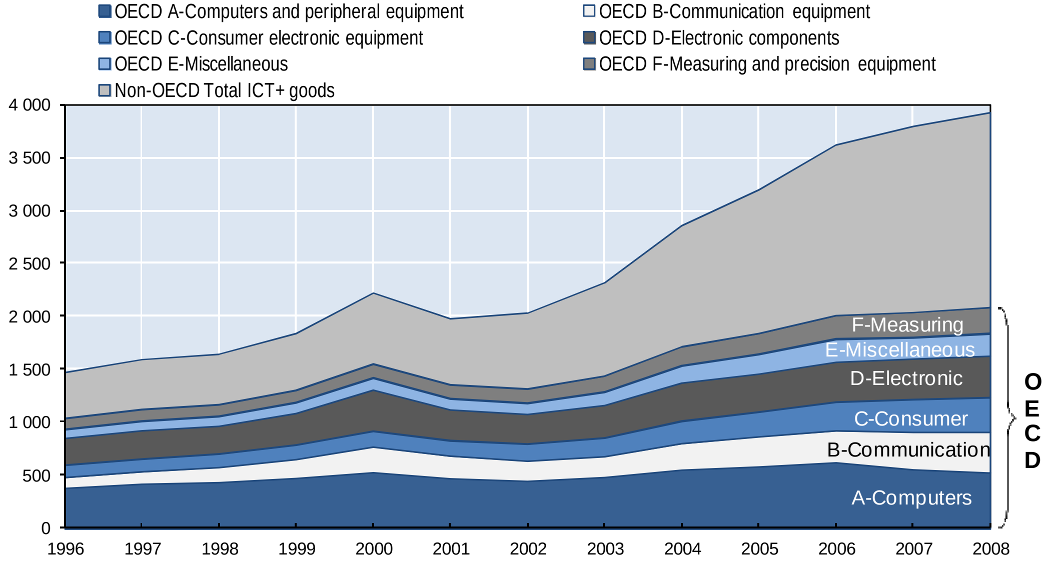
The crisis accelerated the restructuring of global trade and investment

Global trade is growing

Worldwide ICT trade returned to growth following the very sharp decline from the last half of 2008 through the first quarter of 2009. Before the economic crisis, global ICT trade expanded strongly. It approached USD 4 trillion in 2008, having tripled since 1996 and almost doubled the spike of USD 2.2 trillion in 2000. The share of ICT trade in total world merchandise trade peaked at 18% in 2000, but fell to 12.5% in 2008 due to slowing ICT trade, strong growth in non-ICT products and price effects. OECD ICT trade more than doubled to USD 2.1 trillion and accounted for close to 7% of world merchandise trade, but imports outpaced exports and the OECD share dropped from 71% in 1996 to 53% in 2008.

World trade in ICT goods, 1996-2008

USD billions, current prices



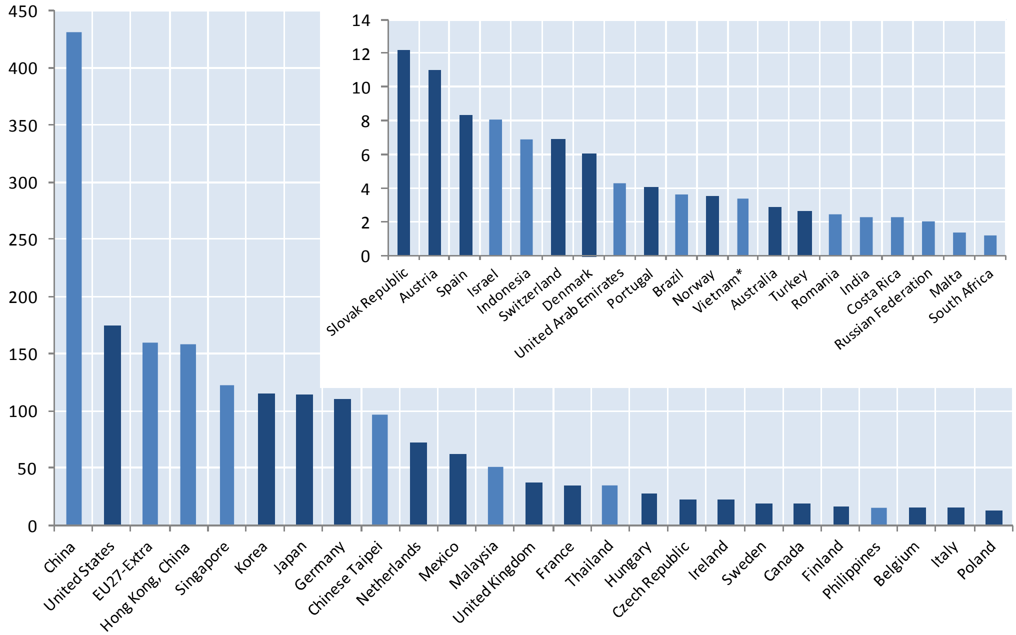
Source: Joint OECD-UNSD ITCS (International Trade by Commodity Statistics) Database, December 2009.

China is the largest exporter of ICT goods and India of computer and information services

Global restructuring of ICT production continues. Eastern Europe, Mexico and non-member developing economies are increasingly important as producers and growth markets. Multinational enterprises, international sourcing, and intra-firm and intra-industry trade have had huge impacts on global ICT goods value chains, and the reorganisation of the international supply of ICT services has been an increasing source of growth. China is by far the largest exporter of ICT goods, very largely driven by foreign investment and sourcing arrangements. India is by far the largest exporter of computer and information services, fuelled by the growth of domestic Indian firms.

ICT goods exporters, 2008

USD billions, current prices



Note: Countries shaded in dark blue are OECD countries.
Source: Joint OECD-UNSD ITCS (International Trade by Commodity Statistics) Database, December 2009.

Asia plays an increasing role in goods production networks that import high-value electronic components for assembly and re-export, and China's role as a production and sourcing location has intensified. In 2008 China's ICT exports were only slightly behind the combined exports of the United States, the EU27 (excluding intra-European trade) and Japan and Korea had outstripped Japan. New supply locations are emerging as the search for low-cost provision and the reorganisation of global innovation and supply chains continue, and countries in Eastern Europe, notably the Czech Republic, Hungary and the Slovak Republic, have benefited from new foreign investment and assembly and export specialisation.

ICT-related FDI declined during the crisis, and non-OECD economies are increasingly active in M&As

Like foreign direct investment (FDI) in general, ICT-related FDI slumped during the crisis. The value of cross-border mergers and acquisitions (M&As) dropped by half, faster than purely domestic M&As, with firms preferring to invest at home. ICT-related M&As declined faster than total M&As from 2007. In 2009, acquisitions of ICT firms accounted for only 11% of the total value of deals, down from the historic high of over 30% in 2000 when telecommunications firms overextended themselves in a buyout frenzy. Non-OECD economies are increasingly active: the share of ICT-sector cross-border M&As targeting and originating in them increased steadily to 33% and 24%, respectively, in 2009.

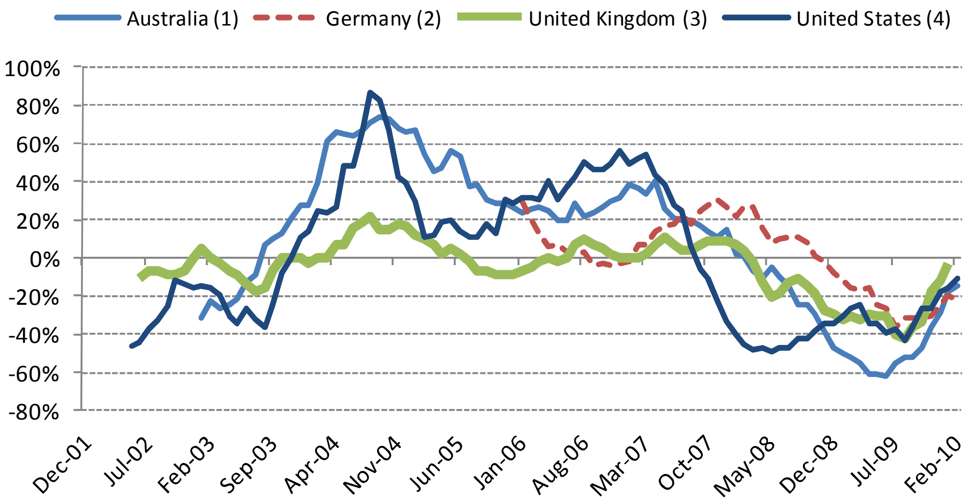
The pressure on OECD ICT employment has begun to lift and vacancy rates are growing

Pressure on OECD ICT employment remains, but declines were less sharp than in 2002-03

ICT and ICT-related employment account for a significant share of total employment. The ICT sector had close to 6% of total OECD business employment in 2008, with long-term growth somewhat faster than for total business. Following the usual recession employment cycle (employment declines lag output declines) employment dropped in ICT goods and remained generally flat in ICT services. However, despite year-on-year falls of 6-7%, ICT manufacturing employment did not suffer the large declines of 2002-03. ICT-related vacancy rates have recovered and were growing month on month by early 2010.

Cyclical changes in ICT vacancies, 2002-10

Year on year

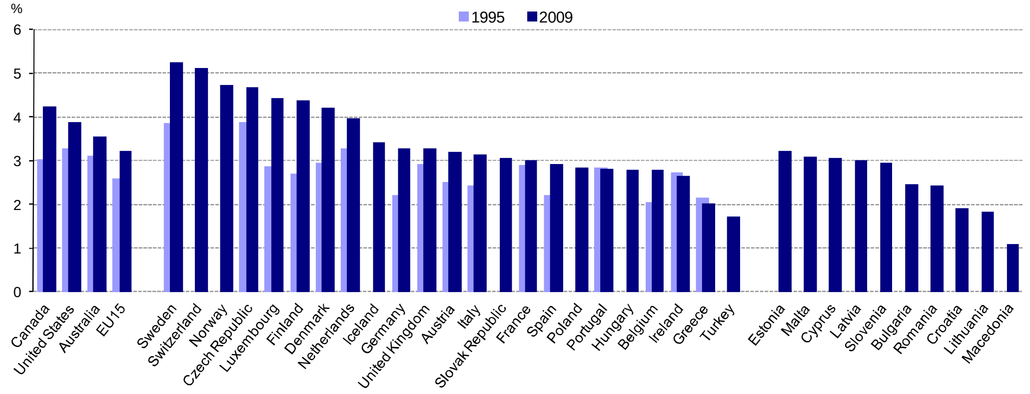


Source: OECD estimates based on national and private ICT vacancies and labour market sources.

The share of ICT specialists in OECD countries is rising consistently

ICT specialist employment economy-wide accounts for around 3-4% of total employment in most OECD countries, with lower shares in Eastern Europe. Women still account for less than 20%; their share is above the OECD average in Finland, Iceland and the United States. ICT-intensive occupations are over 20% of total employment and their share is also rising.

Share of ICT-specialists in the total economy, 1995 and 2009



Source. OECD calculations based on EULFS, US Current Population Survey, Statistics Canada, Australian Bureau of Statistics.

Cloud computing and green ICTs are promising areas for new ICT jobs

Promising areas for new ICT jobs and competences include cloud computing, green ICTs and “smart” applications. The last two have been promoted in government “green growth” stimulus packages. Cloud computing should strengthen demand for ICT specialists but it is likely to have more impact on value added and growth than on employment. Employment in R&D, production and deployment of green ICTs remained relatively stable during the recession and may increase significantly with the recovery. There should be jobs in manufacturing semiconductors for energy efficiency and clean technologies such as photovoltaics, wind power and ICT recycling services, and in the development and use of virtualisation software, and in more efficient and cleaner “smart” applications.

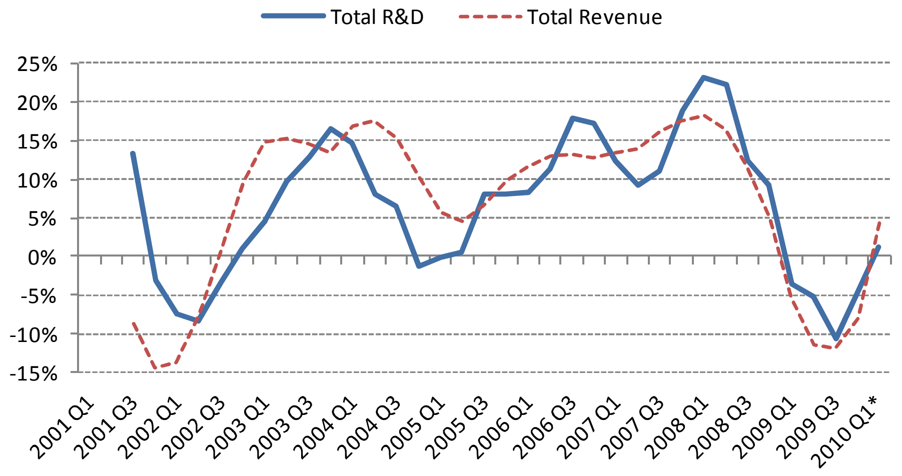
Growth has continued in key areas

ICT-sector R&D maintains its lead

ICT-sector innovation and ICT firms maintained their dominant role among R&D-performing firms during the recession. ICT R&D has tightened its links to firm revenues, tracking the recession and renewed growth more closely than in the past, and ICT firms appear ready for renewed technology-driven growth. Internet and Asian firms are most dynamic, with semiconductor R&D continuing to underpin new ICT inventions and applications.

**Growth in quarterly R&D and revenue of the top 200 ICT firms reporting R&D spending,
Q1 2001-Q1 2010**

Four-quarter moving average



Source: OECD

Access to high-speed Internet is widespread among business and households and continues to expand

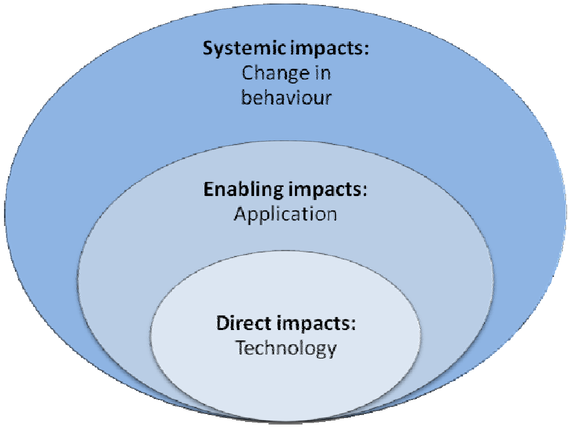
In most OECD countries at least three-quarters of businesses and well over 50% of households are connected to high-speed broadband. Moreover, most OECD governments aim for 100% availability of high-speed Internet for households in the near and medium term. These trends stimulate the development and use of digital content. Most areas are growing at double-digit rates, and for games, music, film, news and advertising, the Internet is transforming existing value chains and business models.

Green ICTs can drive growth and help tackle climate change

The direct impact of ICTs on energy and material use during their life cycle can be reduced …

ICTs are key enablers of "green growth" across the economy and for tackling environmental challenges and climate change. ICTs affect the environment at three levels: direct impacts, enabling impacts and systemic impacts.

Three levels of environmental impacts of ICTs



ICTs have considerable direct environmental impacts in terms of energy use, materials throughput and end-of-life treatment. A basic PC's contribution to global warming is highest during its use phase, but it is also significant during the manufacturing and end-of-life phases. Improved R&D and design can deal with direct impacts throughout the life cycle, and government "green ICT" policies can promote life-cycle approaches (see the *OECD Recommendation of the Council on Information and Communication Technologies and the Environment* at www.oecd.org/sti/ict/green-ict).

ICTs can enable more sustainable production and consumption …

ICT systems enable more sustainable production and consumption across the economy, ranging from product-specific improvements (embedded ICTs for energy-efficient vehicles) to entire systems (ICTs for smarter transport management). ICTs can lead to significant environmental benefits in buildings, transport and energy. In the transport sector green ICTs can reduce travel needs, influence travel choices, change driver and vehicle behaviour, increase vehicle load factors and improve network efficiency.

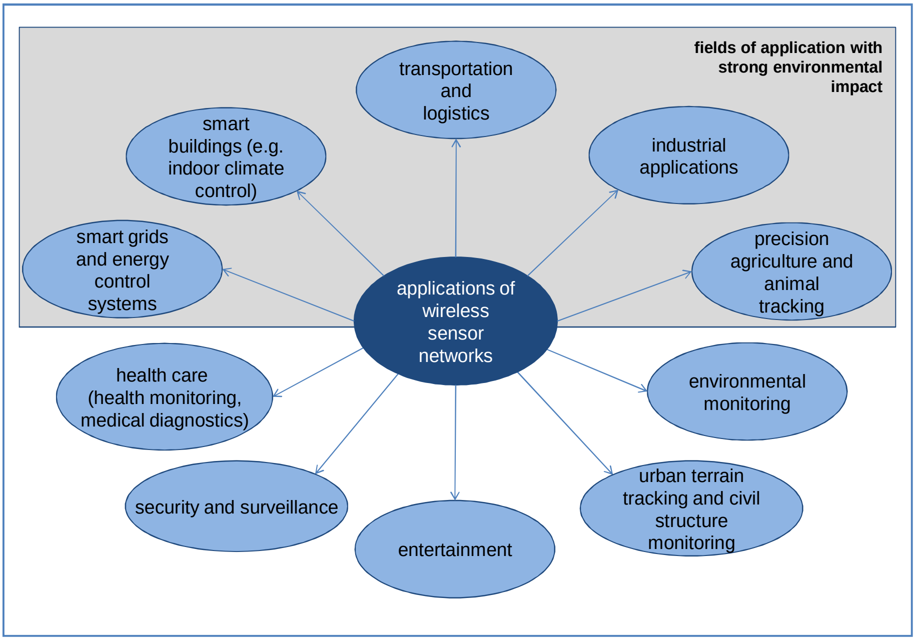
… and underpin systemic changes towards a greener society

ICTs are pivotal for system-wide mitigation of and adaptation to environmental change. Users and consumers can spearhead more sustainable growth through informed decisions based on improved access to reliable environment-related information and information and applications. Further research is needed to understand how ICTs and the Internet can contribute to reaching environmental policy goals by fostering renewable energy and optimising energy production and use, improving the functioning of buildings and urban systems, and reducing transport and material use.

Sensor applications can contribute to more efficient use of resources

Sensor and sensor network applications show particular promise for tackling environmental challenges in energy, transport, industrial applications, precision agriculture and smart buildings. In smart buildings minimum standards of energy efficiency coupled with sensor technology can be a major factor in reducing electricity use and greenhouse gas emissions.

Fields of application of wireless sensor networks



However, rebound effects have to be taken into account …

Although smart grids, smart buildings, smart industrial applications and precision agriculture and farming are expected to have strong positive effects, results for smart transport are mixed owing to rebound effects. Intelligent transport systems make transport more efficient, faster and cheaper, but raise demand for transport and related resources, with potentially negative rebound effects.

… underscoring the importance of government actions

Government policies and initiatives are crucial for achieving the positive environmental effects of sensor technologies and radically improving environmental performance. They can ensure that environmental costs are internalised, for example by raising CO_2-intensive energy and fuel prices. Minimum energy-efficiency standards for smart buildings and smart grids can reduce electricity use and help mitigate climate change. Joint R&D, demonstration and implementation projects can promote industry-wide use of sensor technology and help to develop open standards.

Following the recession ICT policies are helping to foster economic recovery

Most government economic stimulus packages include measures promoting ICTs

Most government responses to the economic crisis include measures targeting the ICT sector and promoting ICT-based innovation, diffusion and use. To boost the recovery, three-quarters of governments have increased the priority of at least one ICT policy area. Recent policy emphasis on areas that contribute directly to short- and long-term growth – ICT jobs, broadband, R&D and venture finance, and smart ICTs for the environment – provides evidence of the key roles that ICT policy can and must play.

Top ICT policies for the economic recovery

ICT policy area
ICT skills and employment
Broadband
R&D programmes
Venture finance
Enabling environmental impacts of ICTs

Longer-term ICT policies take account of the ubiquity of ICTs

Top ten longer-term ICT policy priorities, 2010

ICT policy area	
1)	Security of information systems and networks
2)	Broadband
3)	R&D programmes
4)	Government on line, government as model users
5)	Innovation networks and clusters
6)	ICT skills and employment
7)	Digital content
8)	Consumer protection
9)	Technology diffusion to businesses
10)	Technology diffusion to individuals and households

Longer-term ICT policy priorities are also influenced by the economic crisis, with some differences in the overall promotion of ICT innovation across the economy. The number of governments giving high priority to security of information systems and networks has increased in response to the ubiquity of ICTs in OECD economies and the potential risks of greater reliance on information systems.

ICT policies are now mainstream economic policies

ICT policies have changed considerably in the last ten years. They are now mainstream policies underpinning growth and jobs, increasing productivity, enhancing the delivery of public and private services, and achieving broad socioeconomic objectives in the areas of health care, aging and education, climate change, energy efficiency, employment and social development. As ICT applications and services have become ubiquitous, they have become essential for ensuring sustainability throughout the economy. This makes policy evaluation more crucial than ever to ensure that ICT policy design and implementation are efficient and effective in a time of severe budget constraints in most OECD countries.

FLEX-3, a work in progress

The black box and the Job Study

The productivity development is as important in the long run on the firm level as it is on the national level. This is what makes a firm survive or not, and determines what resources are available for private and public consumption. Productivity analysis is thus essential.

As early as the beginning of the 1990s we who were working at "NUTEK Analys" on different productivity projects felt that something was missing when we tried to explain productivity differences and productivity development on the firm level. The firm internal life was like a black box to us. This is the problem Nathan Rosenberg addressed in his famous book "Inside the Black Box" from 1982, and again in 1994 in "Exploring the Black Box". His interest lies in the knowledge processes that create new things. We have a little broader agenda since we also want to understand the daily process of the firm. We lacked information about how the firm was organised, its strategies and the work practices it used.

In late 1994 we learned about one part of the large OECD-project "The Job Study" that had as one of its objectives to look into these types of questions. We decided to join this effort. The ambition of the group was that Statistics Canada would produce a model survey which would then be used by a number of countries. In 1995 we at NUTEK launched a survey to address this matter. It was directed to the Swedish business sector and the questions were about work organisation and learning. After having analysed this material we produced a book in the beginning of 1996 with our conclusions. Unfortunately we were the only country that made such a survey in this context. However, some years after the project was finished Statistics Canada launched a pilot and after some additional years a regular survey in this field, which still is not the case in Sweden.

What we found when analysing this material was that decentralisation and learning in the daily work was very important to both economic performance and working conditions. This was seen and appreciated by delegates from the ministries of the other Nordic countries that participated in the OECD working group. This led to similar but not identical studies that were carried out in the other Nordic countries. During a year of Swedish chairmanship in the Nordic Council we got the assignment to lead a project with the objective to harmonise the analyses and produce a common report, "Flexibility Matters -Flexible Enterprises in the Nordic Countries". In this project we tried to find out if the results were similar in all countries. In all, this was the case.

In 1997 "NUTEK Analys" also carried out another round of this type of survey. This time the survey data was linked to register data for firms and individuals. The result which was presented in 2001, "Enterprises in Transition Learning Strategies for Increased Competitiveness" was similar to the earlier findings.

The CIS and ICT surveys

During the last decades two very important microdata surveys have been established as standard EUROSTAT surveys: the CIS (or Community Innovation Survey) and an ICT use survey to firms. 2009 is the first year that these two surveys became official statistics in Sweden and thus are mandatory to answer. As a result, the response rate increased significantly.

At the end of 2006 we learned about the MEADOW project, an international consortium of 14 research groups in 9 countries representing both business schools and specialists on working conditions and work practices. We, Hans-Olof Hagén and Annette Nylund, were invited to follow this work closely and also became somewhat involved in it. The Meadow group has scanned the literature, studied the practice and produced two tested model surveys based on this research: one for organisations and one for individuals. This process means that the validity of these questions is good, or as good as it gets. The theoretical base for our analysis is developed in a paper by Annette Nylund; "Work organisation and competence development in Swedish firms"

Sampling frame and questionnaire

The sampling frames for the CIS and ICT survey were for the first time not negatively, but positively coordinated in 2009. This means that 1 900 firms had answered both questionnaires in 2009, compared to just around 400 mostly large firms during earlier years. Of these 1 900 firms, around 500 only had between 10 and 15 employees, and these were excluded because their work organisation is not considered to be that crucial.

We decided to use the Meadow questionnaire for organisations in a telephone survey with the remaining 1 372 or so firms. This of course has a disadvantage in coverage since the innovation survey does not cover all industries in the business sector. Two important industries that are not covered are the construction industry and retail trade. By using the Meadow we got as good a guarantee we could get for having valid questions.

The Swedish questionnaire could be reduced not only because we had access to the other two surveys but also because we could link most of the firms to register data. These register data did not only contain economic data of the firms but also important staff data. The staff data makes it unnecessarily to ask some questions where it is hard to get really good answers in a telephone interview. These kinds of questions are staff composition details such as how many of the employees are: men, women, young, old, their level of education and so on. So far we had a problem with firms in the financial industries since their balance sheets are quite different and the information is not gathered in the same way at Statistics Sweden as the non financial firms. We have some more work to do before these data are integrated in our dataset, so these firms are so far not included in analyses that requires economic data. However we are currently working on this.

The reduction of the Meadow questionnaire was important to raise the response rate to almost two thirds, which is quite a high figure for a voluntary survey. Together with the non-response analyses that indicate that the non-response did not distort our result, we are rather confident that our data are relatively reliable. This is presented in a paper by Lana Omanovic and Martina Aksberg; "Quality of data in the Swedish Meadow Survey".

Numerical and other forms of flexibility

We have used most of the questions in the Swedish Meadow questionnaire to build composite indicators. The choice of indicators in our FLEX-3 study is based on the fact that firms are acting in an environment that change more and more every year. This means that firms' ability to adopt has become a necessity for their survival in the long run and for their economic performance in the short run.

One very important aspect of this is the firm's ability to handle chocks in its demand, even if these are not as profound as the one in 2008. That means that firms have to be able to reduce cost very fast.

Small stocks and use of just in time practices is one part of this but also the ability to reduce labour cost in a short time is important. Thus we have called this concept Numeric Flexibility and tried to capture this by some of the Meadow Survey questions. This concept is also based on the analyses in our earlier flex studies.

However, the firms can also have other types of flexibility in the sense of ability to adept and transform. These other types of flexibility are more of an organic flexibility which means that they can change all the time and pick up signals early, take advantage of new opportunities and react to different threats. This flexibility has been split into two parts in our work: Decentralisation and Learning.

These concepts of decentralisation and learning also have a high degree of human behaviour background. In the literature about human behaviour and preferences, two important aspects have been highlighted: one is the human need to be able to control and be in charge of one's life. This is also true for one's working life. The decentralisation of power to those on the shop-floor, irrespectively if this is in a law firm or in an assembly plant, is essential for the well-being of the people working there. This in turn affects their productivity.

In addition, people want to develop and not to be stuck in one place with no possibility to change. An organisation that lets people develop and learn as individuals as well as lets them be in a context that develops and learns also satisfies a number of basic human needs. The transformation from these theoretical concepts to actual indicators based on survey questions was carried out in our former flex studies. This rich experience has been of great value to us in this work.

The learning concept can be well captured with the questions in the Meadow survey with just one additional question added. This has proved to be very useful in our earlier studies and has also been tested in the Meadow development work. The rich dataset that the Meadow questionnaire has provided has also made it possible for us to extend our learning concept. So this time it has been split into two parts: individual learning and structural or organisational learning.

We believe that in a more decentralised organisation the firms have more contact points outside the firm. Therefore they can easier take in information about new customer demands, changes in the competition or other important developments outside the firm. However, it is even more important that more people can change how they work and act without asking for permission higher up in the hierarchy.

As already mentioned, the learning concept is split into an individual part and an organisational part: into individual learning and structural learning. This concept is also of great importance to the adaptation ability. If the individuals learn more they can change more, thus adapting to a changing environment. The same is true for the whole organisation.

In the paper by Annette Nylund the Meadow consortium's approach towards the relation between theory, empirics and analyses has been interpreted as "the link to theory needs to be constructed ex post rather than be taken as something that has been structuring the original design of the survey". In developing our indicators we have worked in the same way, but also leaned heavily on our earlier flex studies. However, the proof of the pudding lies in eating it, so we have tested our hypothesis that these flexibility indicators catch some fundamental aspects of the firms' work organisation, strategies and work practices, and thus have an impact on both economic and social outcomes of the firms' activities.

The questions that have been used in these indicators are the bulk of the analytical part of the Meadow questionnaire. The only substantial part that is relevant and not included is the firm's relation with the outside word. We will deal with this part later on in the project.

There are also two other groups of questions. One is the about the role of the firm in the value creating chain and the other is the reason behind a possible reduction of the staff. So we have used the majority of relevant questions in our composite indicators.

Reliability

However, to construct a composite indicator it is necessary to decide on the relative importance of each aspect, meaning that we have to choose weights. In order to test how critical these choices are we have performed a sensitivity analysis. This test showed that the ranking of firms by the composite indicators is not very sensitive to the choice of weights. Our conclusion is thus that our data are valid and reliable. Our results are also reasonably representative for the majority of Swedish firms in the business sector, since the sample frames in both the CIS and ICT surveys are representative and their response rate was very high. Together with our high response rate and the outcome of our intensive non-response analyses, we are quite comfortable in this conclusion. All these tests are found in our separate paper: the "Quality of data in the Swedish Meadow Survey"

Of course this is not the case for the industries that are not included in the innovation survey and thus not in our survey. And so far it is not the case for the firms in the financial industries that we have not yet got the relevant economic data. This is also not the case for the micro firms with less than 15 employees, because those organisation forms are not considered to be that critical.

The differences in flexibility

It seems that there are flexible firms in all the industries we have studied and industry means are not that different. However, as expected the more knowledge-intensive industries are on average more flexible, and this is true for both manufacturing and service industries.

The difference in firm size is more marked. The small firms are less flexible with one exception and that is decentralisation. The firms which are more involved in structural learning have significantly more highly educated employees with a university exam and also have relatively more women employed. The women are also clearly overrepresented in firms that are more numerically flexible and more decentralised, and almost in those with more individual learning. The decentralised firms also have a concentration of middle age employees.

However, a comparison between domestically owned firms and foreign owned firms does not show a distinctive pattern, and this is true for small as well as for larger firms. The conclusion is that a foreign owner does not impose its organisational pattern on the Swedish firm it has acquired. Apparently the Swedish model rules. These distribution data are found in the paper already mentioned: Work organisation and competence development in Swedish firms".

Time and causality

The organisational data was collected from December 2009 to February 2010. Most of the questions are about the current situation. On the other hand the survey on innovation and the survey on ICT were finished before the summer of 2009. Most of the questions in these are about the year 2008 but some also concern the situation in

January 2009. The last year that we now have access to in the register data is also from the year 2008. Of course this is not ideal, and we would have preferred if the organisational data had been collected say in 2007. However, there are many questions about 2007 as well as some questions about changes during these years. In many cases the respondent was asked about the current situation and then about 2007. In total there were eight questions of this type in the organisational part of the questionnaire, and an analysis on how many firms that had changed something results in a very stable picture. This means that our picture of the organisational situation was pretty much the same in 2007 as it was when the survey was carried out. Still we have to be rather cautious about the causality conclusions. This means that all our analytical results are still relatively tentative, with one exception the study of long-term productivity impact. However, our findings can also be seen as a starting point for further analysis and research, and we hope to repeat this survey next year and analyse that result and also follow up the impact of this survey's results on coming register data ourselves. We will also continue out our current study another two months and pursue the analysis in some fields.

Innovation and flexibility

More flexible firms are generally more innovative. These findings are presented in our paper by Olof Grünewald: ”Organisation in the black box of innovation”. There is a positive significant relation between all four flexibility indicators and all four modes of innovation: product innovation, process innovation, market innovation and organisational innovation. And all but the numeric flexibility are significantly negatively correlated with the percent of the sales that consists of barely altered goods and services. At the other end of the scale is the percent of the sales that are goods and services that are the result of innovation and new to the market. Here it comes as no surprise that it is the firms that scores high on the learning scale; individual as well as structural that has a positive and significant relationship to this innovation indicator.

We have also used a more sophisticated model that is frequent in innovation analyses, the CDM model. With this model an analysis can be carried out so the influence of many other factors can be taken account of as; industry, staff composition, markets, cooperation and so on. This is also a model that tries to deal with the causality question by addressing the selection biases and using instrument variables and three-stage regression analyses.

This model indicates that the choice to become an innovating firm is not affected by the flexibility but the investment in innovations by the innovating firms. And the efficiency in the innovation process is not affected nor the impact of the innovation results in form of new products and process on the productivity. However this still means that the flexible firms that innovate have a higher productivity via more innovation activities and more new goods and services.

Our conclusion: Flexible firms are more innovative, and this seems to lead to a higher productivity.

Organisation and ICT

We have constructed three composite indicators for ICT use for internal integration as well as external integration. Together, Internet sales and Internet purchases also sum up to a total indicator on ICT use. These are found in our separate paper written by Markus Lagerquist: ”ICT Organisation and Productivity”. With the data available we have been able to capture how the companies have evolved in a forward direction within this definition of ICT. Even though we have kept the definition of what would be a high use of ICT constant over our measuring period, it has still been a relevant measure as it has not yet hit the roof and it is still moving upward. We have showed that broadband has over the period been a relevant prerequisite for enabling higher ICT usage and that the relation between broadband and ICT use goes both ways. There is also support for the theory that broadband through ICT can result in higher productivity.

These indicators have also been used to study the relation between organisation and ICT. All the sub indicators and the composite indicators on ICT use are significantly correlated with three of the flexibility indicators with one exception for one sub index. However, there is a much weaker relation between the indicator of ICT use and decentralisation. Thus it seems that it is not only important with a high ICT standard and extensive ICT use in a very decentralised organisation, but also in a very centralised one.

We have also analysed this relation while taking account of some other variables in the regressions. It did not come as any surprise that numeric flexibility and both individual, even if a little less strongly, and structural learning could explain some of the variation in the ICT use index. This is also true for the decentralisation indicator, even if the significance is somewhat lower.

Organisation and gender equality

Another important aspect that we have studied is the relation between indicators on differences between the two sexes and flexibility. We have constructed a number of indicators for differences between men and women in two areas: the responsibility of children and career and. This analysis is found in the paper by Caroline Ahlstrand: ” Work organisation and differences between sexes”

We have good register data for two areas: parental leave and the right to tend to sick children. In both cases we have counted the number of days that the men and women with children under 10 years use for tending to their children. The indicator measures if any of the sex uses relatively more days than the other within a firm.

When it comes to the other field, career, and the indicators we have picked are the average income and the number with leading positions in relation to the number of each sex in the staff.

We have studied the relation between these types of indexes and also composite indicators for each area as well as a total sex difference composite indicator on one hand and the flexibility indicators on the other. Since other factors could have an important influence on the difference, we have taken account of the influences of age, experience, education, industry and the overall proportion of women in the firm. In all these regressions the indicator for proportion of women becomes significant. That means that our hypotheses that an increased proportion of women in a firm decrease the difference between the sexes are confirmed.

The degree of decentralisation does not seem to have any relation to our composite indicator on difference between the sexes. However, numeric flexibility is negatively related to the difference both for the parenthood indicator as well as the career indicator. The same is true for the individual learning indicator even if with a somewhat lesser degree, while the indicator for structural of learning is significant for the total index and the parenthood indicator but not for the career indicator. Our conclusion is that when individuals are free to choose, they tend to follow tradition to a greater extent than when new things are imposed on them from the organisation. Especially the firms that have a high degree of numeric flexibility and learning have clear staff strategies that they carry out. This seems to somewhat diminish the difference between the two sexes.

Organisation and Working conditions

In this part of the project we want to see if work organisations have an impact on the employee's future. This is a part of the study where we are still very much in a situation of work in progress. It will be presented in a paper by Hans-Olof Hagén.

We have two types of indicators. These are not indicators on the actual working conditions but the outcome of the working conditions. One is the sickness leave for more than two weeks which is based on register data.

We have also constructed another measurement that is also based on register data. The indicators are based on staff data for firms that have answered the Meadow Survey and existed in 2005. We have split them into 6 categories according to their situation on the labour market in 2008. Two of the categories consist of people who are working, either in the same or another firm. The rest are different categories of non-workers: unemployed, on sickness leave, in early retirement or outside the labour market with social security or no benefits at all.

Since the probability to become sick, unemployed and so on differs with age, sex, education, industry and region, we have estimated the probabilities for each individual and aggregated it to firm level. The difference between the average probabilities for an employee in a certain firm to fall into each category and the actual outcome is then our indicator.

The analysis of the relation between these indicators and the flexibility measurements gives just a few significant results. The most striking one is that people working in firms that are to a higher degree of individual learning have a higher risk to be on unemployment benefits or be propelled out of the labour force in the form of early retirement. The last mentioned is also true for the firms that are more into structural learning. It could be interpreted that these firms have a very advanced human resource strategy that includes expelling low performing individuals.Of course this conclusion must be taken with extra caution since this is based on the assumption that their work organisation was the same in 2005 as it was in 2009.

A similar exercise has been done to the register data on long term sickness leave. The numeric flexible firms have a significant higher percentage of their staff on sickness benefits. It also seems that the more decentralised firms have a tendency to lower absentee of this kind than expected due to their staff composition compared with other firms.

Finally we have also tested if the different flexibility modes influence the development of their employees. This has been done using the relative income increases 2005-2008 when taken account of the similar variables as earlier. The employees in the Meadow firms that were more decentralised, and had more of individual and structural learning year 2008 had in relative terms had a better income development 2005-2008. The opposite was true for the more numeric flexible firms.

Organisation and the long term productivity

The basic problem with all our analyses, as has already been stated, is the fact that our organisation data are from a later time than all our other data. Even if we have some indicators that the organisational structures are rather stable, this is still a problem.

We have tried to solve this dilemma in some way by using FLEX-2 data. With help of the questions that were used in this survey in 1997, it was possible to construct indicators similar to those used in the MEADOW questionnaire in FLEX-3 for three composite indicators out of four. It was namely not possible to get a good indicator of our concept of structural learning. This analyses was done by Hanna Wallén presented in the paper: "Organisation and Long-term Firm Development"

The result was very conclusive: firms which scored high in individual learning as well as those that did in decentralisation were more productive and this difference persisted for the whole period from 1998 to 2008. However, for the numerically flexible firms it was the other way around. The most flexible firms were those which performed worst and kept doing so for the whole 10-year period. She has also tested if there are any differences in the risk for the firm to not survive. It seems that the decentralised and individual learning firms also have a significant higher probability to survive.

Main conclusion

Our conclusions:
Our small but rich dataset seems to have rather high quality and our flexibility indicator seems to be robust.

The difference in flexibility was small between industries and somewhat larger between firm sizes. However, more knowledge intensive and larger firms were generally more flexible. And it seems that foreign owners of Swedish firms do not impose other work practices on those used in Swedish owned firms.

The flexible firms seem to be more innovative, more intensive ICT-users and this tends to lead to higher productivity levels. The productivity differences also seem to be persistent over a long time period. The flexible firms, with the exception of the more decentralised ones, tend also to have a somewhat smaller difference between the two sexes than it comes to parenthood and career.

Our indicator on working condition impact single out the numeric flexible firms to be not that positive. Decentralisation seems to be a more positive regime while how the learning firms are judged depends on the employee category.

Quality of data in the Swedish Meadow Survey

Lana Omanovic, Statistics Sweden and Martina Aksberg**, Stockholm University*

1 Introduction

The Meadow Survey has been conducted with the aim to gain a more profound understanding of the organisation of firms that have participated in the ICT[18] and CIS Surveys[19]. This has enabled an improvement of analyses of economic growth and analyses of the impact on individuals such as gender equality and working life.

Collection of more detailed data on firms' strategy, organisation and work practices in the Meadow Survey is a prerequisite for further studies about the relationship between organisation, the use of ICT and innovations and their joint impact on growth and productivity in firms aw well as for a broader analysis agenda.

Due to restrictions in the availability of data, earlier Flex studies have investigated the relationship between the use of ICT and productivity and the relationship between innovation and productivity separately, and in much less detail. By contributing with information on firms' organisation, the Meadow Survey attempts to enable a study of the combined impact of the use of ICT, innovation and organisation on firms' productivity and growth.

A prerequisite for the reliability of results of the analysis is an increased understanding of the reliability of data collected in the Swedish Meadow Survey. In order to gain an improved understanding of the quality of data, several analyses have been carried out. These include an analysis of potential selection-bias in sample, a non-response analysis, an analysis of the weighting of index components in the index measures, and a robustness check.

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**Martina Aksberg -BSc Mathematical Statistics, Stockholm University

[18] Statistics Sweden, Use of ICT in Swedish enterprises 2009

[19] Statistics Sweden, Innovation activity in Swedish enterprises 2006-2008

Finally a test of the validity of the Meadow Survey measures over time has been done in order to see if the data selected in the Meadow Survey is representative for firms' organisation over time and can be matched with other data sources. In this paper the procedures and results from the analysis of data are presented.

2 Selection frame

Firms that have been selected to participate in the Meadow Survey comprise all active firms that have participated in both the CIS and ICT Surveys and have more than 15 employees. This is because small firms tend to have an ad hoc organisation rather than defined work practices.

The selection in the Meadow Survey consists of 1 374 firms, i.e. it includes all firms that fulfil the above mentioned criteria for qualifying for the Meadow Survey, except for 21 firms that are no longer active due to closures or acquisitions. The Survey was made through interviews with representatives for the top-management level within the firms. At firsthand interviews where made with CEO:s within the firms. In the case that it was not possible to gain contact with the CEO within a firm, another representative for the top management of the firm was chosen for the interview, e.g. the HR director. The aim of conducting the Survey on the top management level was to collect information from people that have a high level of responsibility for the firms' activities and a good overview of the organisation within the firms. For more details about the selection frame, see the section Swedish Meadow Survey 2010 in the paper Work organisation and competence development in Swedish firms[20].

2.1 Response rate

Among the 1 374 firms selected to participate in the Survey, 881 have responded, contributing to a 64% response rate in the survey. Among the non-responding share of 36%, about half of the firms have been unable to reach while the remaining half have refused to participate (about half of these firms have refused to participate due to firm practice against participation in voluntary surveys).

[20] Annette Nylund (2010) "Work organisation and Competence development in Swedish Firms, based on the Swedish Meadow Survey 2010", Yearbook on Productivity 2010, Statistics Sweden

When compared to the response rate in the ICT and CIS Surveys, 84% and 85% respectively, the response rate of 64% in the Meadow Survey can be regarded as satisfactory considering that participation in the Meadow Survey is voluntary while both the ICT and CIS are EU regulated mandatory surveys. The response rate of 64% can be viewed as satisfactory for a voluntary survey conducted in Sweden and high when compared to other international voluntary surveys of firms. For more details about the response rate across industries and firm sizes see the section Swedish Meadow Survey 2010 in "Work organisation and competence development in Swedish firms".

Table 1
Response rate Meadow Survey

Cathegories	No of firms	Share (%)
Selection	1395	
overcoverage	21	
	1374	100
No or responses	881	64.1
whereof		
complete interviews	874	63.6
partial interviews	7	0.5
No of non-responses	493	35.9
whereof		
unable to participate	6	0.4
unable to reach	235	17.1
declined participation	252	18.4

Some underlying reasons for the relatively high response rate are probably foremost the use of register data on individuals and the piggy-backing of the CIS and ICT Surveys which combined have made it possible to reduce the number of detailed questions asked in the survey and limit the time of the interviews to 15-20 min. In addition, combining the information sources has made it possible to make a more profound non-response analysis.

2.2 Non-response analysis

In order to assess how representative the responses in the Meadow Survey are for the entire sample of population, a non-response analysis has been conducted by using background information from the CIS and the ICT Surveys[21].

Variables based on background information are created for the firms included in the sample and comparisons between the respondent group and non-respondent group are made. The comparison of the non-response group and the response group is done across three categories of background information:

- ICT indicators
- Innovation indicators
- Economic indicators

The category ICT indicator includes one composite index (Itcompositindex08) and all of its component variables. Among these components three variables (Itsystem08, Customsupply08 and Infirm08) measure the degree of ICT integration within the firm and between the firm and its environment. The two remaining ICT variables, Shareorderinternet08 and Internetpurchase08, are basic variables.

The innovation indicator variables cover the central aspects of innovation in firms, including four innovations modes (Neworg08, Newprocess08, Newprod08 and Newmarketing08) and two innovation output measures (Sharenewtomarket08 and Sparenewtofirm08).). In 2009 all the four innovation modes were included in the Swedish innovations survey; not only product and process innovation but also organisational innovation and marketing innovations. The innovation output measures include share of new products or services in sales that were introduced to the market during 2006-2008, including those that were new only to the firm and those that were new to the market.

Economic indicator variables included cover different measures of productivity: turnover per employee which is an approximate measure of efficiency, value added per employee which is the traditional productivity measure and average wage cost per employee which is a measure of quality of labour force.

[21] See footnotes 2 and 3

It is assumed that firms that have similar values for the background ICT, innovation and economic indicators are not likely to display significant differences in the Meadow variables.

In order to compare the ICT-, innovation- and economic indicators for the responding firms and the non-responding firms, mean values for 15 already described variables are calculated for three groups of firms: the sample, the response group and the non-response group.

As a second step, a comparison of the mean values is done across the three groups of firms.

Two tests are carried out.

In the first test comparisons are made of the mean values of the non-response group and the sample and the response group and the sample. The first test is carried out on an aggregated level, i.e. no distinction has been made for the size or industry of the firms included in the groups in the comparison.

It is evident from table 2. that there are only minor differences between the average values for ICT-, innovation- and economic indicators variables for the responding and non-responding firms in comparison to the sample. The largest deviations from the sample mean values for variables for the response and non-response groups can be seen in the ICT indicators, yet these differences in means can be considered as small.

Table 2
Mean values for background variables for the sample, response and non-response group and comparison to sample mean values

	Background Variable	Mean value			Relationship mean values	
		Sample	Response	Non-response	Response/ Sample	Non-response/ Sample
ICT Indicators	Itcompositindex08	25.38	24.14	27.52	0.95	1.08
	Itsystem08	39.37	38.12	41.50	0.97	1.05
	Customsuply08	20.79	19.13	23.64	0.92	1.14
	Infirm08	46.06	44.81	48.21	0.97	1.05
	Shareorderinternet08	10.04	9.06	11.72	0.90	1.17
	Internetpurchase08	10.66	9.57	12.53	0.90	1.17
Innovation indicators	Neworg08	0.42	0.42	0.41	1.01	0.99
	Newprocess08	0.41	0.41	0.41	1.00	1.00
	Newprod08	0.46	0.46	0.45	1.01	0.99
	Newmarketing08	0.33	0.33	0.33	1.00	1.00
	Sharenewtomarket08	0.04	0.04	0.05	0.92	1.15
	Sharenewtofirm08	0.04	0.04	0.04	1.04	0.92
Economic indicators	Etp_net_turnover_per_empl	3769.88	3979.82	3406.21	1.06	0.90
	Etp_value_added_per_empl	850.38	823.56	896.82	0.97	1.05
	Etp_wage_a_soc_costs_per_empl	539.68	530.16	556.17	0.98	1.03

It should be noted that only 1 197 firms of total of 1 395 firms in the sample are included in the comparison of economic indicators variables due to unavailable data for 198 firms on the number of employees.

In the second test a categorisation of firms within the sample, non-response and response groups is done according to firm size and comparison of mean values is done for each category of firms in the non-response group and response group with the corresponding category of firms within the sample. The firm sizes are categorised in three groups: small (15-59 employees), medium (50-249 employees) and large (250-999 employees). Firms with more than 999 employees are excluded from the comparison. Firms with less than 15 employees have already been excluded at the sampling stage in the Meadow Survey. In addition, the 198 firms with no available information on the number of employees are not included in this second comparison.

Table 3
Mean values of background variables for sample, response and non-response group categorized by firm size and comparison to sample

	No of employees	No of employees	Mean value			Relationship mean values	
			Sample	Response	Non-response	Response/ Sample	Non-response/ Sample
ICT Indicators	Itcompositindex08	15-49	17.31	17.06	17.83	0.99	1.03
		50-249	26.35	24.7	29.53	0.94	1.12
		250-999	36.50	35.74	37.68	0.98	1.03
	Itsystem08	15-49	25.46	25.6	25.17	1.01	0.99
		50-249	38.33	37.16	40.59	0.97	1.06
		250-999	51.98	51.81	52.23	1.00	1.00
	Customsupply08	15-49	12.34	11.82	13.41	0.96	1.09
		50-249	20.73	18.67	24.7	0.90	1.19
		250-999	33.97	33.21	35.16	0.98	1.04
	Infirm08	15-49	32.88	33.08	32.45	1.01	0.99
		50-249	50.65	48.52	54.74	0.96	1.08
		250-999	65.01	64.23	66.23	0.99	1.02
	Shareorderinternet08	15-49	5.84	5.77	5.99	0.99	1.03
		50-249	9.85	7.86	13.68	0.80	1.39
		250-999	18.22	17.54	19.28	0.96	1.06
	Internetpurchase08	15-49	10.04	9.03	12.13	0.90	1.21
		50-249	12.19	11.30	13.92	0.93	1.14
		250-999	13.31	11.92	15.50	0.90	1.16
Innovation Indicators	Neworg08	15-49	0.31	0.30	0.31	0.99	1.02
		50-249	0.44	0.42	0.46	0.97	1.06
		250-999	0.53	0.56	0.48	1.06	0.91
	Newprocess08	15-49	0.29	0.29	0.28	1.00	0.99
		50-249	0.42	0.41	0.43	0.99	1.02
		250-999	0.55	0.56	0.54	1.01	0.98
	Newprod08	15-49	0.36	0.38	0.31	1.06	0.88
		50-249	0.43	0.43	0.44	0.99	1.01
		250-999	0.60	0.61	0.60	1.00	0.99
	Newmarketing08	15-49	0.28	0.30	0.23	1.08	0.83
		50-249	0.32	0.29	0.38	0.91	1.18
		250-999	0.39	0.37	0.43	0.94	1.10
	Sharenewtomarket08	15-49	0.04	0.03	0.04	0.98	1.03
		50-249	0.04	0.04	0.05	0.95	1.09
		250-999	0.05	0.05	0.05	1.00	0.99
	Sharenewtofirm08	15-49	0.03	0.04	0.02	1.18	0.64
		50-249	0.04	0.04	0.05	0.93	1.13
		250-999	0.05	0.05	0.05	0.99	1.02

Table 3 (continued)

	No of employees	No of employees	Mean value			Relationship mean values	
			Sample	Response	Non-response	Response/ Sample	Non-response/ Sample
Economic Indicators	Etp_net_turnover_per_empl	15-49	3852.62	4210.40	3111.00	1.09	0.81
		50-249	4138.82	4212.05	3997.73	1.02	0.97
		250-999	3628.16	3623.25	3635.85	1.00	1.00
	Etp_value_added_per_empl	15-49	734.55	720.83	762.99	0.98	1.04
		50-249	1012.15	906.78	1215.18	0.90	1.20
		250-999	881.14	879.45	883.80	1.00	1.00
	Etp_wage_a_soc_costs_per_empl	15-49	517.81	514.13	525.43	0.99	1.01
		50-249	548.68	537.18	570.84	0.98	1.04
		250-999	554.50	545.36	568.84	0.98	1.03

The results presented in Table 3. show that there are no large differences in the mean values for the background variables for the non-response group and the background variables for the response group compared to the sample, also when taking into consideration the size of the firms in the comparison.

The tests carried out in the non-response analysis indicate that there are no larger differences in economic condition, innovation activity and ICT use for the non-responding group of firms compared to the sample and the responding group and the sample. Therefore it is possible to assume that there are no significant differences in the survey variables across the non-responding firms and the responding firms, and that the responses received in the Meadow Survey can be considered representative for the whole sample of firms.

3 Composite indices

The Meadow Employer-level Survey questionnaire has been created by an international research consortium and follows MEADOW guidelines which are the output of the EU project Measuring the Dynamics of Organisations and Work (MEADOW). When conducting the Meadow Survey in Sweden the Swedish version ”Arbetsgivarenkät – Sverige” of the Meadow Employer-level Survey questionnaire has been used.

While conducting the survey, the Interviewing Unit at Statistics Sweden has made minor adoptions to the Swedish version of the survey using all the questions in the questionnaire except questions related to information which has been collected from registers and the ICT and CIS studies. The Background and Method sections in the paper "Work organisation and competence development in Swedish firms" describes the Meadow project in more detail as well as the different information sources used in the Swedish Meadow study.

Based on the data collected in the survey, four indices measuring Structural Learning, Individual Learning, Numeric Flexibility and Decentralisation have been created.

Variables that measure different features of the firms in the Meadow Survey have been created and are all based on data collected in the Meadow Survey. When creating the four indices, a selection of variables that are relevant for the composite indices has been done to create the four concepts of individual learning, structural learning, decentralisation and numeric flexibility. The incoming variables have been weighted by appointing different weights to the incoming components. The selection of variables and their weights when creating the indices has been based on experience and theory. For a more thorough analysis of the validity of the composite indicators please see the section: Four composite indicators in "Work organisation and competence development in Swedish firms".

In the Flex 2 study the aspects of Numeric flexibility, Individual learning and decentralisation and their impact on firm productivity have already been investigated. The paper Organisation and Long-term firm development[22] investigates the long-term relationship between Numeric flexibility, Individual learning and Decentralisation in firms with productivity.

Meanwhile, the updated version of the Meadow Survey used in the Swedish Survey has allowed for the construction of the index for Structural learning. In the updated version of the Meadow Survey a number of questions associated with structural learning have been included which has made it possible to include this measure in the Swedish study.

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[22] Wallén Hanna (2010), MSc candidate, Royal Institute of Technology. "Organisation and Long-term Firm Development", SCB productivity Yearbook 2010

As already mentioned, the selection of the composites has been done based on theory and previous experience meanwhile the implication of appointing weights for their relative importance within each separate index is unknown. In order to investigate the implication of appointing weights to the components within each index tests of robustness have been conducted.

3.1 Test of robustness

In order to study the importance of the choice of weights for the incoming components of the four indices, individual learning, structural learning, decentralization and numeric flexibility, a sensitivity analysis, i.e. test of robustness, is conducted for each index.

First, the data set consisting of 881 observations i.e. firms is divided into five groups of firms, according to their Swedish Standard Industrial Classification (SNI) 2007 code, representing five different industries in the manufacturing and service sector.

Table 4
Overview of industries used for organisation of data

	Industry	(SNI 2007)
Manufacturing	Labor Intensive	10, 18, 22, 25, 31-33
	Capital Intensive	16, 17, 19, 24, 35, 39
	Knowledge Intensive	20, 21, 26-30
Service	Trade & Transport	46, 49, 53
	Knowledge Intensive	58, 61, 63-66

In the analysis the four different indicators, presented in table 5 have been tested. The four indicators have been weighted with random weights (ranging in value from 0 to 1) after which the firms within each industry have been ranked according to their value on the index being tested. This has been done for a thousand alternative weights. A separate test is conducted for each index for each of the five industries, i.e. in total 20 separate tests are conducted.

This technique has been used in a previous empirical study by Statistics Sweden[23], by the Directorate for Science, Technology and Industry (DSTI) at OECD, and by the analysis institute FORA which

[23] Hans-Olof Hagén (2004); “Background Facts on Economic Statistics, Comparing Welfare of Nations” 2004:15, Department of Economic Statistics, Statistics Sweden

works for the Ministry of Industry and Finance in Denmark[24]. The program generates a list of the number of times each observation, or firm, has been ranked with highest position within this index among the firms in the group, the second highest position etc. down to the lowest possible position i.e. the lowest possible position of a firm equals the total number of the observations within the group.

To obtain an overall picture of the results the average position for each of the firms within the industry is calculated.

Table 5
Overview the indices and their input components

Index	Input components
Individual Learning	1) Daily learning
	2) Share paid education
	3) Share unpaid education
	4) Share employee talk
	5) Share feedback
Structural Learning	1) Frequent team meeting
	2) Share team improvement
	3) Evaluate prod-services
	4) Data document update
	5) Follow-up external ideas
	6) Share employee talk
	7) Customer satisfaction
Numeric Flexibility	1) Trained to rotate
	2) Share part-time
	3) Share temp-work
	4) Share rent crew
Decentralization	1) Hierarchic level
	2) Task decision
	3) Quality decision employee
	4) Share decision work team
	5) Share flex work

[7] For example this has been used in a study by Jens Nyblom and Lotta Langkilde, "Et Benchmark Studie at Innovation og Innovationspolitik", FORA

In the next step a list of rankings of observations (i.e. firms) is created based on the firms' value of index when using equal weights for the incoming components of the index while calculating the value of index (in this case all weights have been set equal to 1).

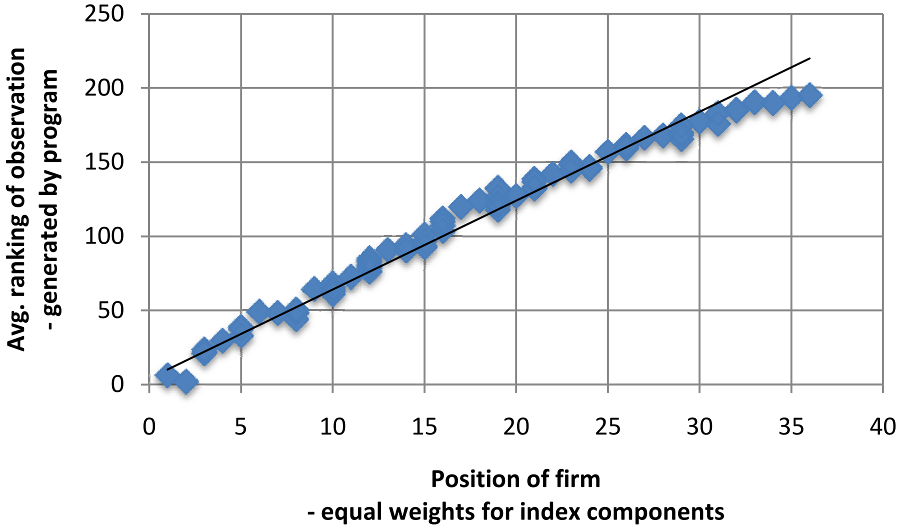
A comparison of the average position for each observation when using random weights and the position when using equal weights is done. The scatter plots in Figure 1. a) through d) show the relationship between these two positions for firms for each of the four indices for the Labour intensive industry.

As indicated from figure 1. a.) through d.) there is a rather strong linear relationship between these two positions for all the four indices for firms in the Labour intensive industry. This implies that the order of firms, i.e. the position for that index, is not to any large extent affected by weights chosen for the incoming components of the index. This relationship applies for all four indices within the Labour intensive industry. This relationship seems to be the strongest for the decentralisation index while it is somewhat weaker for the Numeric Flexibility index and higher positions of the index for Individual Learning and Structural learning.

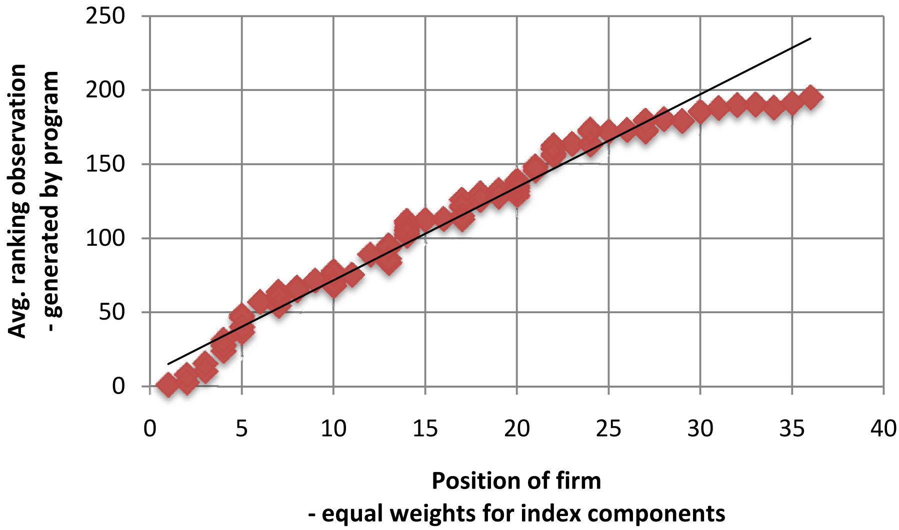
To illustrate in more detail, a firm in Figure 1.a.) which has the position 6 on the horizontal axis has been ranked as the 6th firm within the Individual learning index when using equal weights for index components and value 50 on the horizontal axis means that this same firm is ranked as 50 in average when index is computed with non-equal weights (generated by program).

Figure 1
The relationship between rankings of firms with equally weighted components compared to avg. rankings of firms using random weights of index components generated by program for firms in the Labour intensive industry

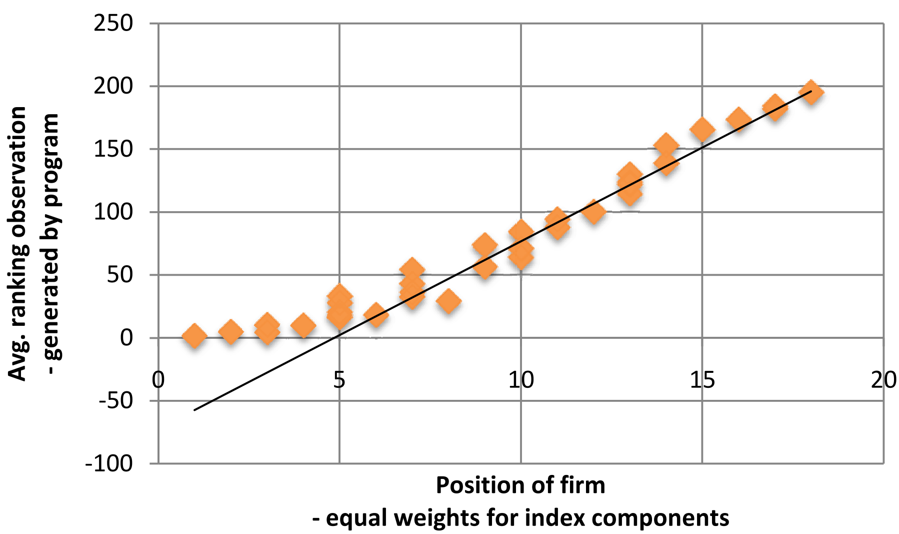
a) Individual Learning



b) Structural Learning



c) Numeric Flexibility



d) Decentralisation

Figures 4. - 7. in Appendix demonstrate this relationship for firms within Capital intensive manufacturing industry, Knowledge intensive manufacturing industry, Trade & transport industry and Knowledge intensive service industry. It is evident that there is a rather strong linearity in the relationship of the position of firms for the four indices within all four groups of firms that constitute the four industries.

The results indicate the ranking for all firms with respect to their indices measuring: Individual learning, Structural learning, Numeric flexibility and Decentralisation are rather independent of the size of the weights chosen for their components.

4 Time and Causality

The variables included in the four indices consist of information of cross-sectional data about firms activities related to individual learning, structural learning, decentralisation and numeric flexibility at the time the information on firms' organisations was collected i.e. from December 2009-February 2010.

Meanwhile, the data from the CIS and ICT Surveys deal with information relating to 2008 and the beginning of 2009. The latest available register data on firms is from 2008.

To see how representative the organisational data collected in the Meadow Survey is for firms' organisational structure in 2007, a test has been conducted.

In the organisational part of the survey questionnaire, 8 questions measuring the existence and level of activity related to structural learning, decentralisation and numeric flexibility in firms in 2007 have been included. For an overview of the components which have been included in this analysis see Table 6.

Table 6
Questions from Meadow questionnaire regarding firms' activities in 2007

Measure of	Activity in 2007 (question no)	Response options
Decentralization	(41.) Did any of your employees work in a team, where the members jointly decide how work is done, 2 years ago?	1. Yes 2. No
	(49.) Could any of the non-managerial employees at this firm choose when to begin of finish their daily work 2 years ago?	1. Yes 2. No
Structural learning	(45.) Did any of your employees participate in a group to think about improvements that can be made in the workplace 2 years ago?	1. Yes 2. No
	(54.) Did your firm monitor quality, of its production processes or service delivery, 2 years ago?	1. Yes, on a continuous basis 2. Yes, on an intermittent basis 3. No 4. Not relevant
	(58.) Did employees in this firm regularly up-date databases, that document good work practices or lessons learned, 2 years ago?	1. Yes 2. No
	(60.) Did this firm monitor external ideas of technological developments (for new/improved products, processes or services) 2 years ago?	1. Yes, using staff assigned specifically to this task 2. Yes, as a part of the responsibilities of general staff 3. No
	(62.) Did this firm monitor customer satisfaction (through questionnaires, focus groups, analysis of complaints or other methods) 2 years ago?	1. Yes, on a regular basis 2. Yes, but infrequently 3. No
Numeric flexibility	(52.) Compared with 2 years ago, has the percentage of employees trained to rotate tasks with other workers?	1. Increased 2. Decreased 3. Remained approx. the same

In the second step, an analysis has been done of the number of firms that have stated that they have made changes to any of these eight activities during the two-year period 2007-2009.

Figure 2
Number of changes of activities in firms during the 2007-2009 by number of firms

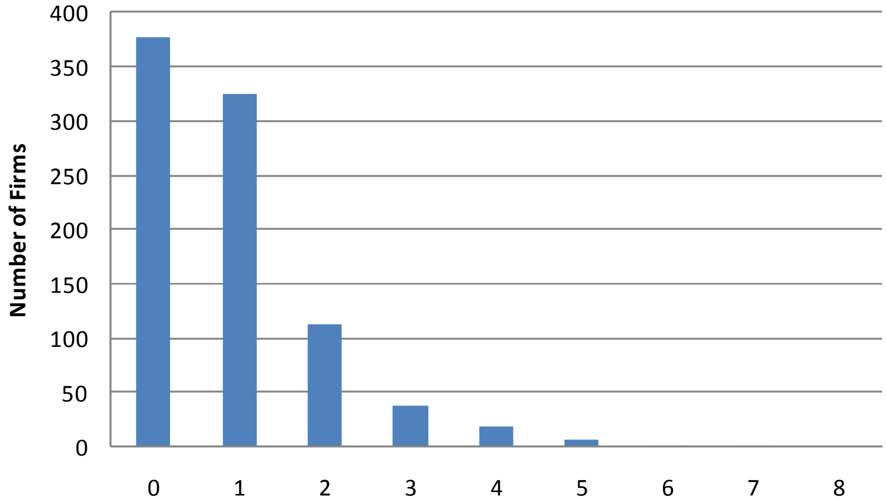


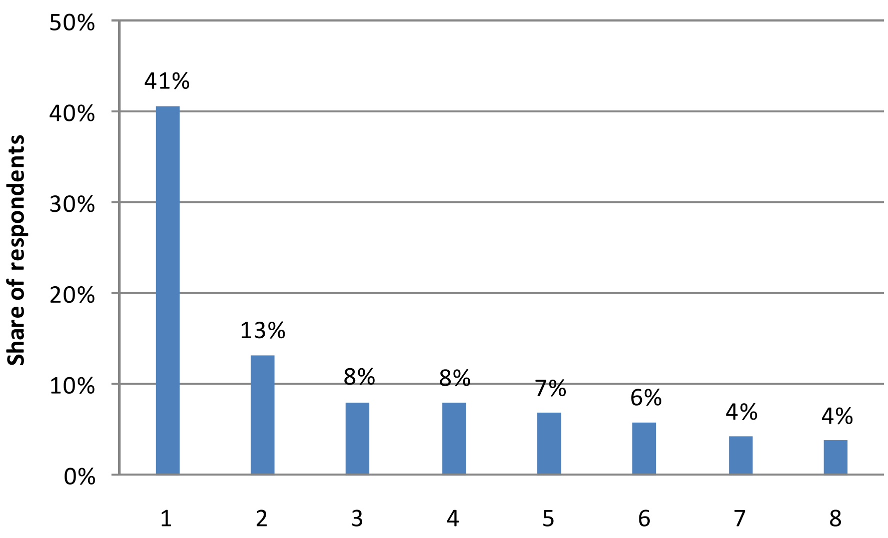
Figure 2. displays the distribution of the number of firms and their corresponding change of activities during the period 2007-2009. Among the 881 firms in the sample, 377 firms claim that they have made no changes with respect to activities related to individual learning, structural learning, decentralisation and numeric flexibility during the period 2007-2009. 325 firms claim to have made a change in one of the activities while 122 firms claim to have made a change in two of the activities over the period 2007-2009.

In total, 43% claim to not have changed any activities while a majority of firms (50%) claim to have only changed one or two activities in the firm related to the four indices during the period 2007-2009.

When analysing the change of activities within the Meadow firms, it is interesting to know what type of activities in firms have changed over the period 2007-2009. When analysing the most frequent type of change that the responding firms have done, it is evident from Figure 3 that a majority of firms have made changes in activities relating to their numeric flexibility. More than 40% of respondents claim to have made changes in the share of employees trained to rotate tasks with other workers. This is followed by changes relating to structural learning where about 13% of the respondents have made changes in employee activities relating to improvements in the workplace. Other types of changes in activities are less frequent and have been made by fewer than 10% of respondents.

Among the different types of activity changes analysed within the firms, change of the number of employees trained to rotate tasks with each other is the most common type of change within the companies in the Meadow Survey during the period 2007-2009

Figure 3
Type of activities that have changed over the time 2007-2009 by share of responding firms



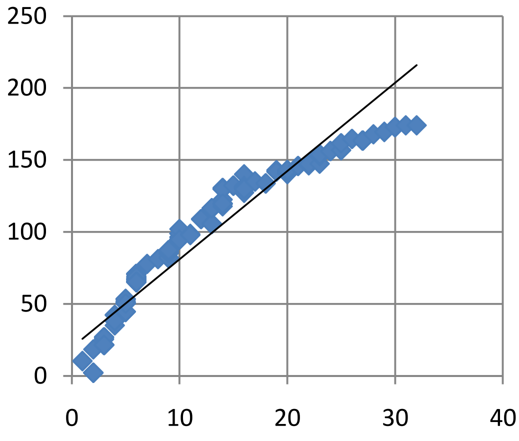
	Activity that is measured over time
1	Change in share of employees trained to change/rotate tasks with others
2	Employees are part of group that meet regularly to reflect about improvements that can be done in the firm
3	Firm follows up & evaluate quality of production processes or services
4	Databases documenting task-rutin/experiences are regularly up-dated by the employees
5	Employees work in groups where the members themselves together make the decision about how work shall be done
6	Firm measures customer satisfaction
7	Employees without management-task can decide about their working time, when they leave from/come to work
8	Firm follows up external ideas/technological change when it comes to improved products/processes/services in the firm

The results indicate that although the data on firms' organisation that is gathered in the survey is cross-sectional organisational structures seem to be stable over time for the firms included in the sample. Therefore the measures of structural learning, individual learning, decentralisation and numeric flexibility should provide a rather good measure of firms' activities in these fields over time for firms included in the sample.

APPENDIX

Figure 4
Capital Intensive industry

a) Individual learning



b) Structural learning

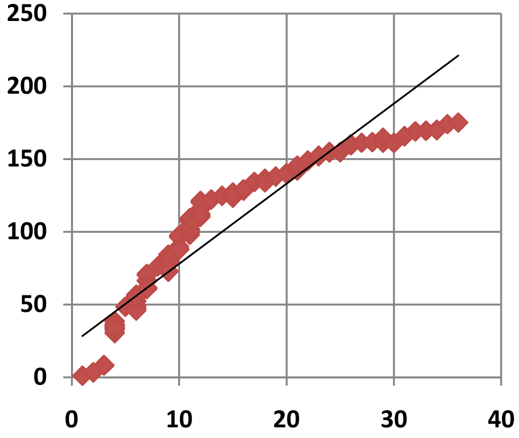
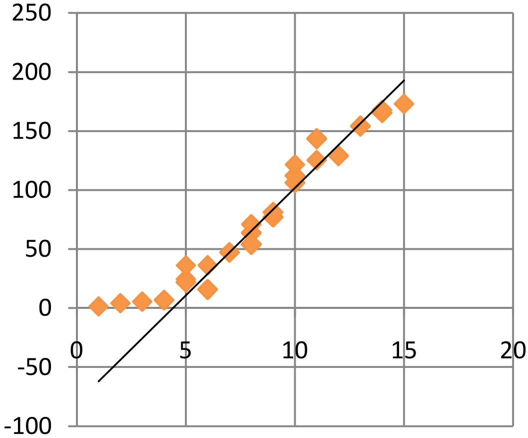


Figure 4 (continued)

c) Numeric flexibility



d) Decentralisation

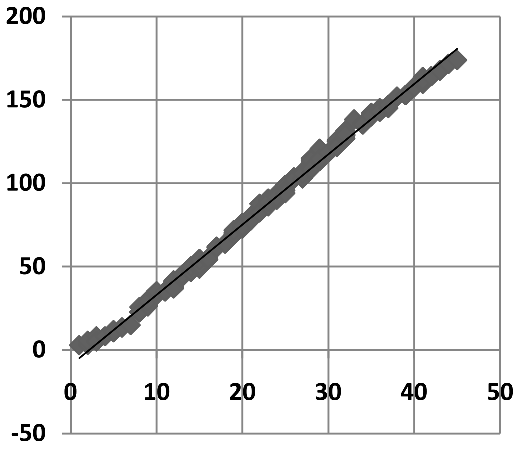
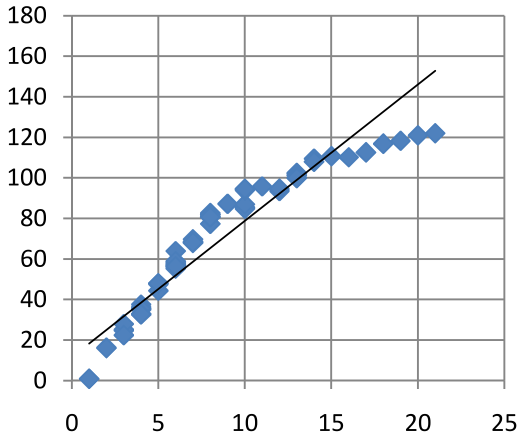


Figure 5
Knowledge intensive manufacturing industry

a) Individual learning



b) Structural learning

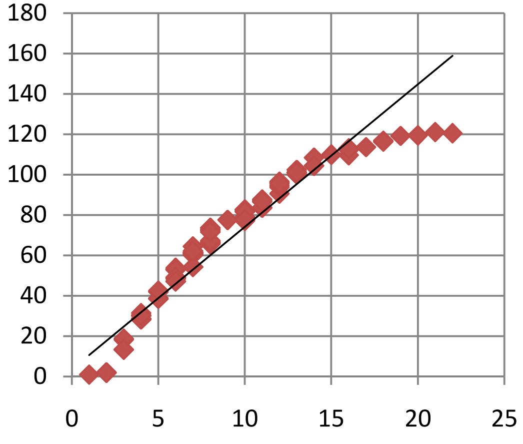
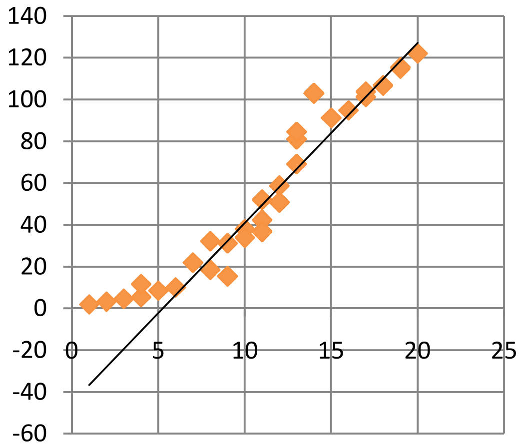


Figure 5 (continued)

c) Numeric flexibility



d) Decentralisation

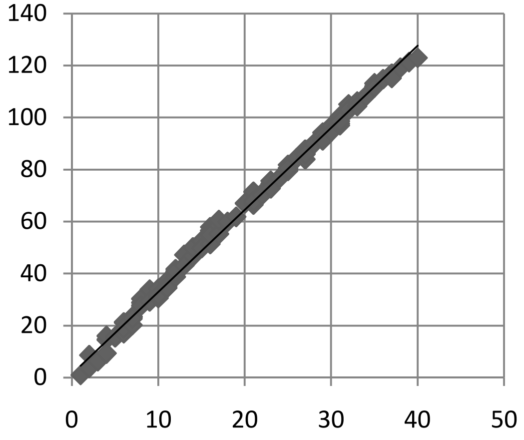
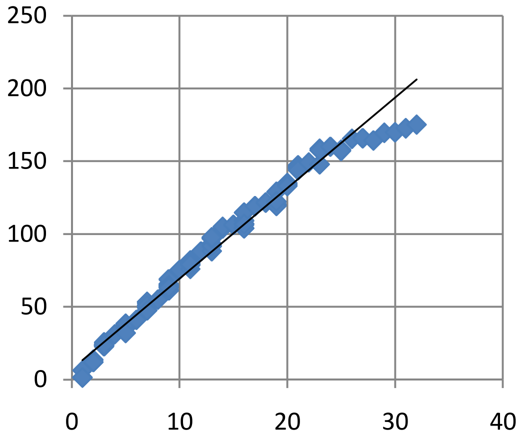


Figure 6
Trade & transport services industry

a) Individual learning



b) Structural learning

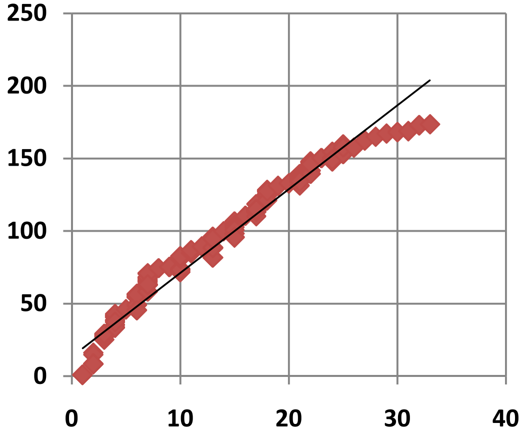
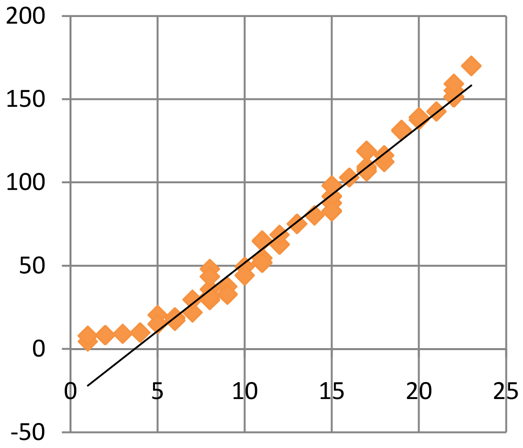


Figure 6 (continued)

c) Numeric flexibility



d) Decentralisation

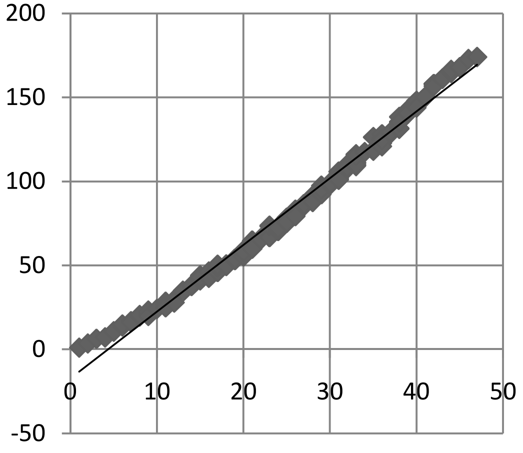
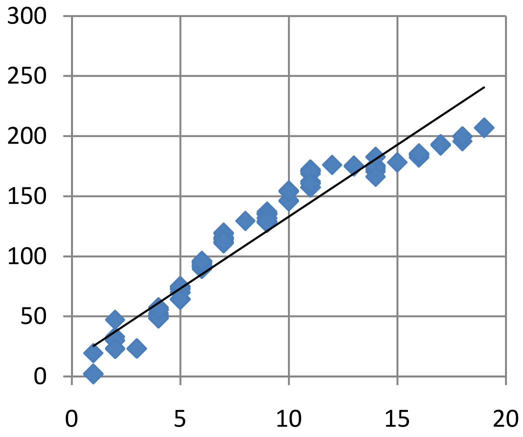


Figure 7. Knowledge intensive services industry

a) Individual learning



b) Structural learning

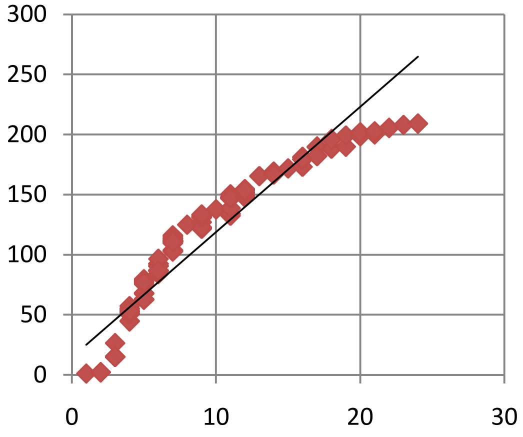
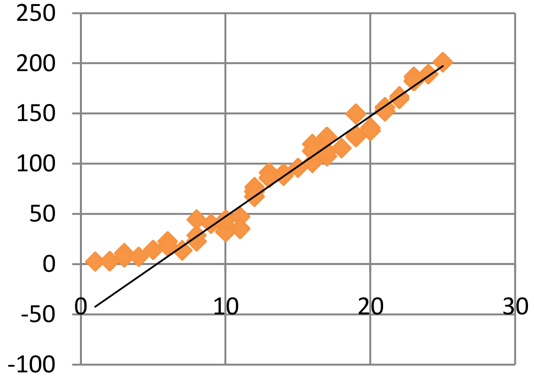
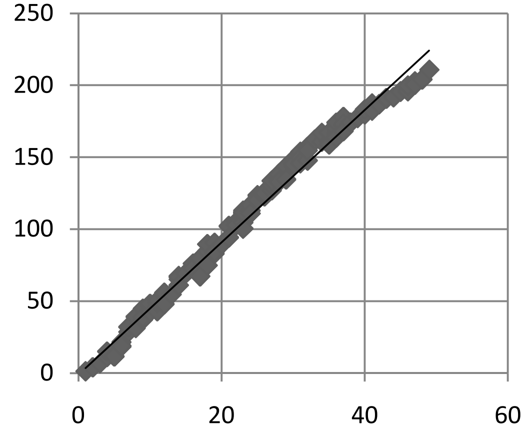


Figure 7 (continued)

c) Numeric flexibility



d) Decentralisation



Work organisation and competence development in Swedish firms

Based on the Swedish Meadow Survey 2010

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Abstract
The overall objective in this paper is to contribute to the discussion about growth in the economy. This can be done in many ways. Here it is done by exploring measurements created by researchers with focus on work organisation and competence development. The results and predictions of incidences of work organisation and competence development across the Swedish business sector are presented. Data from the new Swedish Meadow Survey is used that collects information from the employer. Background theory and data are also described and used in a tentative and exploratory way. By doing so, the paper also can spread knowledge of the EU Meadow project that provides the guideline to the Swedish survey.

Summary and concluding remarks

The overall objective
This study and paper is a part of the Statistic Sweden project called Organisation, Growth and Work. The overall objective in this paper, and also the Statistics Sweden project, is to contribute to the discussion about growth in the economy. This can be done in many ways. In this paper and project it is done by exploring measurements created by researchers with a focus on work organisation and competence development in work. Hopefully this paper will also spread knowledge of the EU project *Measuring the Dynamics of Organisations and Work*, Meadow, which provides an important guideline to the Swedish survey from Statistics Sweden.

This paper aims to support the other studies in the Statistics Sweden project with background theory and descriptions of the measurements used. It also aims to analyse the predictions of incidences of work organisation and competence development across industries in Swedish business sector.

Underlying theories

The EU project is comprised of three main reports, where the main report is a proposal of collection and interpretation of data presented in the Meadow Guideline. Two meta-studies have also been published in the project: the Grid Report, a summary of questions in 21 earlier surveys that aims to pick out the best questions to the guideline, and the Meadow Multi-Level Theoretical Framework, presenting underlying theories behind the examined 21 surveys. The overall conclusion of the background reports is that it increases validity and reliability considerably in the Swedish survey that is using these guidelines. Nevertheless, it is of interest to give some more specific comments on the presented theory.

The presentation of theory in Meadow is divided into three levels: system level, organisation level, and individual level. My first remark is that it seems to be an understanding that the system level includes theories about research and the educational system, and that it also concerns innovation in products and markets etc. which includes both systems and strategies within an organisation. But it does not seem to be equally obvious that these perspectives on systems are intertwined with organisational innovations such as work organisation and competence development, even though it is mentioned that they can be parallel.

When it comes to theoretical aspects concerning the organisational level, the focus is on practices within the firm and on the employees in the firm. The focus is not on interaction between organisations or interaction between employees in different organisations. One of the important aspects that are presented is that employees are seen as a valuable resource for the business strategy and employees are looked upon as proactive and learning. On the other hand, the theoretical perspectives on individuals are focusing on how actions in the firm impact on employees, especially on the so called negative impact on the employees' working conditions and health. It also touches questions about labour market.

One important conclusion concerning the background reports is that the outcomes of the these broad theoretical meta-studies may contribute to theoretical insights, but the link between theory and data needs to be constructed ex post rather than be taken as something that has been structuring the original design of the guideline. This is also highlighted in the Meadow guideline.

Therefore, this first paper wisely uses these theories as well as the data tentatively. The measurements do not take a stand in any of the specific concept; they simply indicate incidences of several of the aspects, and broad indicators are created and used.

Four composite indicators
Four composite indicators are used as proxies of the employer's point of view of the firm's organisation and development. To summarise, the first indicator is a proxy for the employer's perspectives of *individual learning* in the firm that includes the employees' formal and informal learning at work. The indicator *structural learning* provides information if the firm is building structural capital through organised work with quality and innovations as well as strategies about customer satisfaction in focus. The indicator of *decentralisation* gives information about who is responsible for planning daily work and quality control. It also provides some information about horizontal integration in teams, which in itself can indicate the complexity of the organisation. *Numerical flexibility* provides information about the firm's possibility to change the size of the workforce with short notice. It also gives some information about workforce flexibility within the firm in terms of task rotation and part time work. This indicator might also indicate the use of an external workforce for knowledge transformation, at least in combination with other work features.

Relationships between the indicators
The correlation analyses and the regression model provide information of predictions of incidences of the four composite indicators. The correlation gives an overview and studies the relationship between one feature at the time and the indicators. The regression model fine tunes the information and takes into consideration a more complex model of the firm and the work force.

If the correlations are high it can be interpreted as if the indicators and sub-questions provide the same kind of information. It can also be of further interest to analyse multipliable effects if they are correlated. If they are negatively correlated it can mean that they exclude each other.

The correlations between all indicators are positive, except for the relation between decentralised work organisation and numerical flexibility, as more or less assumed. The level of significance is high in the positive correlations, which means that the higher the incidence of one indicator the higher the incidence of the other indicators. This might be an indication of a multipliable effect when using more than one indicator. The highest correlation is between the two learning indicators, and it is 31 percent which is not too high. When it comes to the negative correlation between decentralised work organisation and numerical flexibility the significance level is lower. A negative correlation means that the higher the incidence of one indicator the lower the incidence of the other indicator, and vice versa. Numerical flexibility is still positively correlated with the two learning indicators. The overall interpretation of the parameter estimates are that they are not so highly correlated that the indicators provide the same information.

Work force features predict incidences

A linear regression model is used to estimate the incidence of each of these four indicators, with the help of non dependent variables that measure features of the firm: size and industry and foreign ownership. The features of the firm's work force are also measured: age, formal education and the degree of women and men in the firm. The non dependent variables are assumed to predict a higher or lower incidence of the four composite indicators, one composite indicator at the time, in separated equations. The non dependent features are included in the estimation simultaneously, but the result of one feature at the time can be interpreted and analysed if it provides information that can predict incidences of the indicator, given that all the other included features are held constant.

The result show higher incidences in larger firms and lower in smaller firms, compared to middle sized firms. This is true for all indicators but decentralisation. Another independent feature is the work force sexes. The average proportion of women in these industries is about 30 percent, which gives an average of 70 percent of men. According to the result of the analyses, sexes can predict the incidence. A higher percentage of women predicts higher incidence of three of the indicators, strongest for numerical flexibility. The estimations are highly significant for numerical flexibility, rather high for decentralisation, and significant but to a low level for structural learning. This means that the proportion of sexes of employees in the firm can help to predict the incidence of these three indicators, but not individual learning.

Types of industries cannot really explain the differences between the incidences of any of the indicators, and the incidences do not differ between if the firm is foreign and Swedish controlled. An important reason for why the indicators do not differ dramatically according to ownership, is that foreign direct investments in Sweden are dominated by mergers and acquisitions etc and not so called greenfield investments. Other reasons are that the industrial relations seem to be strong and stable and the knowledge level is fairly high across industries in Sweden.

Policy conclusion
The policy conclusion is of interest since these kinds of practices are of great importance for the development of the firm and of importance for the people working in these firms as well as for the labour market and potential new employees. Above it is stated that the practices are underrepresented in small firms. Moreover, some indicators are significantly underrepresented if the employees have a low educational level. Earlier analyses in the 1990s of the same kind of practices showed a significant relationship between individual learning and decentralisation as well as higher productivity and better working conditions for the employees. Some preliminary results based on this new data also indicate the same results (see footnotes 59 and 56). Since earlier policy programmes promoting these practices have proved to be efficient both when it comes to increase of these kinds of practices and their impact on the firms productivity, there is a reason for developing programmes that are boosting learning and decentralisation (see footnote 69).

Swedish Meadow survey constitutes a good starting point for analyses
Finally, it is worth mentioning in this summary that this paper also describes the Swedish Meadow Survey and quality, alongside other parallel papers in the project, see footnote 42. One important aspect is the selection frame that is based on two EU regulated surveys: The Swedish CIS survey about innovations and the ICT survey. Together with the Meadow Survey they comprise a great potential to make analyses of intertwined perspectives of dynamic changes on a system level and work organisation and competence development in firms and its impact on employees. Several of the presented background theories concerning innovations can be found the CIS Survey, and some issues can be found in the ICT Survey. Data from these surveys have been used in parallel papers to this one, and the relationship between innovation and work organisations as well as competence development are analysed, see footnote 56. Relations between ICT and work organisations and competence development

are also analysed, see footnote 57. Other parallel papers concern analyses of the difference between the sexes and employees' working conditions according to work practices, see footnotes 58 and 59. Together the three Swedish surveys cover in principle all themes of questions in the Meadow Guidelines, and since their selection frame is based on business numbers, the survey data can be matched with several other register data at a low cost with really high quality. The organisation of the Swedish Meadow increases validity (quality of the questions) and reliability (the consistency of the measurement) considerably. Therefore forthcoming papers can even include further analyses of the relationship between the firm and its environment, and economic performance, as well as the employees' position on the labour market given for example their formal education. The overall conclusion is that the first Swedish Meadow Survey, its organisation with other surveys and register data, constitutes a good starting point for further analyses.

Background

The background of this paper is the need for complementary ways to describe driving forces for growth. Classical economical growth models primarily describe changes in growth rates on aggregated levels and even though it is good that they stand out for aggregated mathematical input and output models, they have to be complemented. Today, even economists call these models "the black box" because they lack a description of what is taking place in the firm. The principle idea behind these traditional aggregated methodological assumptions is the desire to sum up the result of the entire economy, since all activities count. A complementary argument is that analyses on disaggregated levels based on growth in businesses, industries or enterprises can give the wrong impression, due to resource allocation and different values of output between economic sectors, businesses, industries and firms.

New endogenous growth theory emphasises that activities in the firms are important to understand value creation and economic growth. Therefore, growth economists argue that the models are especially in need of development when it comes to explaining endogenous activities, and they need to include theories about the firms[25]. Economists who are looking to do so argue that new data is needed to develop theories about driving forces.

But still very few economists are interested in theories of work organisation and learning. One explanation for this is probably related to the traditions in the different theoretical disciplines. Theories of work organisation and learning are often based on qualitative in-depth studies of a single workplace or a single firm. Sometimes some few firms are included, but never or very seldom a larger number of firms. These kinds of deeper qualitative analyses are not mentioned to be aggregated to the business level, or mentioned to be used in an input and output model, or other equations explaining the production function of the economy.

At the same time, targets for policies today are to create new jobs by investing in people and by increasing innovations in firms in the business sector. These policies that prioritise in meeting an increasing demand of lifelong learning, research and development in the knowledge-based society need background information. Moreover, the rapid diffusion of ICT and global markets has increased the knowledge intensity. Alongside traditional emphasis on research and development and investments in third-level science and technology education within the European Union, knowledge in a broader social framework has been recognised. This includes skills development on all levels of the firm. Knowledge-based policies, such as the European Strategy for Growth and Jobs as well as the revised Lisbon Strategy for 'flexicurity', depend critically on indicators monitoring incidences and diffusion of these broader aspects of knowledge and skills.

Therefore, it is in order to argue that there is a growing consensus that knowledge has become of great importance for wealth creation and that innovation is a key driver of economic growth.

[25] Romer P, 1994, Journal of Economic Perspectives, volume 8, No 1, pp 3-22. *The Origins of Endogenous Growth*.

These questions are acknowledged in the European Union project Meadow, an acronym for Measuring the Dynamics of Organisations and Work[26]. The result from the project is a proposal of EU guidelines in the collection and interpretation of new data about work organisations, management and work practices as well as human resource development.

With help of these guidelines created by researchers with focus on work organisation and competence development, new data can be collected that might better fulfil the needs of endogenous growth theory to study activities in the firms and its relationship with value creation and economic growth.

Objective

The overall objective is to contribute to growth and prosperity, by participating in the joint discussion among disciplines about endogenous activities in the economy. This can be done in many ways. As mentioned above, theories of work organisation and learning are often based on qualitative in-depth studies of a single workplace or a single firm, seldom a larger number of firms. Economists in general emphasise that studies of economic growth must be done on an aggregated level, on national or other system levels. Researchers involved in endogenous growth theory support the idea of aggregated growth perspectives, at the same time they argue that it is important to look into activities within the business sector and within the firm. The different disciplines can meet in studies based on firms. Hopefully they meet in this study.

This paper use measurements and data that are created by researchers in disciplines that focus on work organisation and competence development at work, often with focus on so called cases studies. Here these measurements are aimed to be used in aggregated analyses. Further, this paper aim to support the Statistic Sweden project Organisation, Growth and Work, with background

[26] Meadow Consortium, 2010. *Meadow, Measuring the Dynamics of Organisations and Work*. http://www.meadow-project.eu.. The EU-project, running from the last quarter of 2007 to the first quarter of 2010, constituted of a multi-disciplinary consortium of 14 partners in 9 European countries, supported by key institutions responsible for data collection and dissemination, including OECD, Eurostat, and the European Foundation for the Improvement of Living and Working Conditions, the European Agency for Safety and Health at Work, and DG employment. Founded by the DG Research European Commission, Priority Seven (Citizens & Governance) 6: e RTD Framework Programme.

theory from the EU project Meadow, and it especially describes the EU project Meadows theory paper. Hopefully it can contribute in making the EU project more known and spread. This paper also describes the Swedish survey that is collecting data of work organisation and competence development at work, based on the guideline in the EU Meadow project. It also describes used measurements and to a certain extent it explores data and these used measurements. Finally the paper analyses the prediction of the used measurements' incidence and diffusion across the business sector.

Method

Overall frame

The overall frame for this study is the EU project Meadow 2007-2010 and its proposal of how to collect data of skills in firms. The guideline is based on two major background reports; The Grid report and The Theoretical Framework. Both background reports are large meta-studies, the first of empirical surveys and the second of theory related to this surveys. Part of the EU projects background is two earlier Swedish surveys and studies that analyses work organisation and competence development and their impact on people and firms in Sweden during the 1990s. They were organised by the Swedish National Board for Industrial and Technical Development, Nutek, see also footnote 48 and 49.

New data describing work organisation and competence development have been collected in Sweden mainly based on the guideline in the EU Meadow project. The collection of data has been done by Statistic Sweden in the project called Organisation, Growth and Work Environment. The selection frame for the Swedish collection is based on two other surveys. The restrictions and possibilities that this constitutes are decribed in the paper.

Analyses based on the new Swedish data will be published by Statistics Sweden. These are partly inspired by the two Swedish surveys from Nutek that were included in the EU project. The earlier Swedish survey data was used to analyse the relationship between work organisations and competence development in firms, its economical impact on the firms and its social impact on employees.

New survey data matched with individual and firm register data

The data used to measure work organisation and competence development in the Swedish business sector is from a new Swedish survey called the Swedish Meadow Survey 2010. Statistics Sweden has collected data from firms in the Swedish business sector during the winter 2009/2010. Two other surveys constitute the selection frame for the Swedish Meadow Survey 2010, the survey's themes, and questions as well as other frame and used measurements are presented and discussed further on in this paper.

To describe the diffusion of incidence of work organisation and competence development in the Swedish business sector Meadow data are matched with register data that, in addition to economic data, classifies the firm's size, type of industry and foreign control of firms in Sweden. The source of register data is briefly presented below.

Statistics Sweden's longitudinal integration database for health insurance and labour market studies, with the acronym LISA, complements survey data in this study. The register holds primary annual records from 1990 for all individuals aged16 and older who were registered in Sweden as of 31 December of each year. The individuals are connected to family, firms, places of employment etc.[27].

The Swedish Agency for Growth Policy Analysis (Growth Analysis) is the official provider of statistics on the internationalisation of the Swedish business sector including foreign controlled firms in Sweden, as well as some other statistics on firms.[28] *This agency and Statistics Sweden are working together to provide statistics on* foreign controlled firms in Sweden. *In this paper firm data from the*

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[27] Statistics Sweden, 2009. *Longitudinell Integrationsdatabas för Sjukförsäkrings- och Arbetsmarknadsstudier (LISA) 1990-2007.* Arbetsmarknads- och utbildningsstatistik, 2009:1.The individual section includes: Age, Genus, Education, Employment, Unemployment, Income, Professional, Entrepreneurial activities, Illness, Parental leave, Rehabilitation, Retirement, Private pensions, etc. The firm section includes: Firms, Work places, Type of industry, Sector, Location, Number of employees and Salaries per year, Basic economic data. LISA does not include data in the finance and insurance industry (Nace 64-66) since these data is differently collected. In the Statistics Sweden Book 2011 data for all industries will be included.

[28] The database for foreign controlled firms in Sweden includes organisational number country, country groups, business classification, size, employees, if the firm is active.

Swedish Meadow survey are matched with data of firms' controlled by foreign ownership.

The firm is the observation unit

The data from Meadow are matched with register data with help of information from the Swedish Business Register[29]. In the register the firms have both a business number and an organisational number. The business number is a statistical definition of a firm unit. The majority of all business units are defined as a sole legal unit and have an organisational number (it can also be a person's identity number, depending on the type of business). In statistics, the business unit is the smallest economic entity with employees that produces goods or services.[30] According to the registers' administrators[31] the absolute majority of all firms in the register have a so-called one to one relationship between the legal and business unit numbers. Larger firms often consist of more than one legal unit and they often belong to a group of firms. These firms can be organised in the register so that related legal units belong to one common business unit, which can include both active and non active legal units. They are also called complex business units. The idea is that all business units that are related have a common identity, for example if they belong to a group of firms. Mainly the register includes all units that perform actively economically in both private and public sector.

Before the 1990s the statistics of the performance of the business sector was very much focusing on manufacturing activities, because of the tradition of good statistics in these industries on the work place level. This level was in most cases the same as an economic entity with a specific geographical address. Measurements of service activities were poorer in Sweden and there were no measurements of economic activities on the work place level. This was partly because this level did not exist as an economic entity in service business and because many service activities are not taking place at

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[29] Statistics Sweden, 2010. Företagsdatabasen (FDB) 2009. NV0101, The European Parliament and the Council regulate the definition of business and legal units that are used in common statistics, analyses and publications. Regulation of business and legal units (EG) Nr 696/93 and Regulation of Nace rev. 2 (Nace 2007) (EG) nr 1893/2006.

[30] Limited liability firms, or other types of enterprises, or types of economic organisations, or sole proprietorship etc.

[31] Statistics Sweden, Swedish Business Register: Berit Westerholm.

one specific address in a measurable geographic place, as activities in manufacturing. Since then the measurement of service activities has developed considerably, both in terms that they are measured and in terms of how they are measured. Sweden can today be seen as part of the frontier in Europe when it comes to developing measurements in service industries in the economy[32].

Today it is possible to measure economic activities in both manufacturing and services on the same level, using information of business number and organisational number. Therefore business activities from both manufacturing and services are included in this study. The measurements are on a level that has common features, for instance that they are legal units and economic entities, so the basic quality in the analyses can be seen as high. Further the definitions of this unit for all business activities are based on common European regulations, see also footnote 29.

Another reason for measuring at firm level is that investments in management practices and work organisations will be related to innovations and use of information technology, which have to be studied at a level where these decisions and economic decisions are held together according to these measurements guidelines, see footnote 36. In general this level is the legal unit that is the same as the economic entity, called firm in the business sector.

Statistical analyses

Descriptive statistics are used to present the incidences and diffusion of the four composite indicators in the business sector. The diffusion is described according to sizes of the firm, different industries and if the firms are foreign controlled.

The estimation of each firm's incidences are standardised for the firm's own industry's proportion of value added in the business sector, except for firms in finance and insurance industry (Nace 64-66) since these data are differently collected, see footnote 27. One way to study how well the included firms are representing their industries is to calculate their value added, and how well they represent the value added in their own industry or group of industries. The way the firms differ from how they should represent their group of industries can be described in terms of their weight.

[32]Example: Statistics Sweden, 2008, Yearbook on Productivity 2008. Article: Lennartsson D, Lindblom A, Nilsson F. *Developing and implementing a survey on intermediate consumption for the service sector in Sweden*.

The ratio of value added is calculated as the sum of all included firms in relation to the entire value added in the industry or group of industries that the firm belongs to. If each industry was equally well represented the ratio would be the same in all industries. Some industries are over represented and others are underrepresented. The idea is also to use the weight in the different analyses, including the presentation of incidences and diffusion of work organisation and competence development across the business sector in Sweden.

The most common measuring of the degree of correlation is used, the Pearson correlation coefficient. It is widely used in the sciences as a measure of the strength of linear dependence between two variables. The motive is to study the relationship between the indicators and the relation between all included sub questions within each of the four composite indicators. If they are too much correlated they might be providing the same kind of information, if they are not highly related to each other they can be contributing with specific information. A third correlation analysis is done between the indicators and some features of the firm and the firm's workforce.

Finally, a linear regression model is used in further analysis of the prediction of incidences of the four used indicators. The questions answered are if certain features of the firm or features of the employees working in these firms can explain a higher or lower incidence of the four composite indicators. Included features of the firm are size, business unit and if it is foreign controlled or not. The features of the work force are age, sexes and formal educational level. The model estimates for one feature at the time and in the same time standardises for all included features.

Swedish Meadow Survey 2010

The first Swedish collection based on the Meadow guideline was performed during the winter of 2009/2010[33]. Information was collected by telephone interviews from the employers in the Swedish business sector. The questions are based on the Meadow Guideline, see footnote 26 and the former Nutek surveys, footnotes 49 and 50.

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[33] Statistics Sweden, 2010. Danielsson F. *Field report from the collection.* Örebro."Fältrapport" by Frida Danielsson Undersökningsledare, Statistics Sweden/Intervju. Collection took place in November 30th to December 17th 2009, and January 11th to February 19th 2010.

Selection frame

The selection frame for Swedish Meadow Survey consists of 1 395 firms, divided into two rounds of collection. The first one consisted of all firms with 20 employees or more and the second consisted of 395 firms with 15 employees or more. The known over coverage is 21 firms that should not have been in the selection, since they are acquired, insolvent, or not active.

Executive directors in the selected firms were invited to participate in the Swedish Meadow Survey, in a telephone survey. If the executive director could not participate he or she had to appoint another respondent. The field report from the Swedish collection states that it was more problematic to replace the executive director as a respondent in the largest enterprises than in others, see footnote 33. Some of these executive directors decided not to participate, which was possible since the survey is not mandatory or otherwise regulated. One reason for the difficulty to find a replacement in larger firms could have been that it is more common that the larger firms are so-called complex business units, which includes more than one legal unit. On the other hand the total frequency of these complex firms in the present selection is small, only 13 firms[34], implying a rate of less than one percent (0.9). Half of them did not respond, 7 firms, and half did respond[35].

Piggy-backing two other surveys

The Swedish Meadow Survey that provides data of work organisation and competence development is piggy-backing two other surveys that are collecting data from firms in Sweden. Piggy-backing means that these surveys constitute the frame for the selection of firms in the Swedish Meadow Survey.

The first survey the Swedish Innovation Survey to firms, based on the European Community Innovation Survey, CIS.[36] It is a

[34] Statistics Sweden, 2010. Sandra Dovärn Department for Economic Statistics (Investments, R&D, ICT).

[35] Nylund A. Calculation of complex business units in the selection, responded compared with non responded firms.

[36] Statistics Sweden, 2009. *Innovation activity in Swedish enterprises 2006–2008*. The survey is based on a joint guideline between OECD and Eurostat, called Oslo Manual. OECD and Eurostat, 2005. *Oslo Manual Guidelines For Collecting And Interpreting Innovation Data.* A joint publication of OECD and Eurostat, 2005. Third edition. And OECD, 2002. *Frascati Manual Proposed Standard Practice for Surveys on Re-search and Experimental Development.* Paris. The first Oslo Manual focuses on

measurement of scientific and technological activities that is conducted every second year. The second survey is the Swedish Information and Communication Technologies Survey, ICT[37], which collects yearly data from households and enterprises. These two other surveys are EU-regulated and mandatory.

The technique to use two other surveys as the selection frame makes it possible to match data, and to reduce the Meadow Survey. The data set in the other surveys includes business and organisational number that make it possible to match all data in the three surveys and to match with other registers that organise data after these numbers. It is plausible to argue that the technique to match with other data increases both validity and reliability of these data since the surveys that are collecting these other data have been used several years and because the information is specifically collected from the person who knows most of the specific matter.

Neither the CIS nor the ICT Survey includes all industries in the business sector; therefore all industries are not included in the Swedish Meadow. Table 1 presents the included industries and the amount of employees that are included in the Swedish Meadow Survey.

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technological product and processes innovation (TPP) in manufacturing, the second expands to cover service sector but still focusing TPP. The third and latest revision also includes non technological innovation such as marketing and organisational innovation, as well as a systematic dimension of innovation such as innovation linkages.

[37] Statistics Sweden, 2010. *Use of ICT in Swedish enterprises 2009*. The survey is based on a manual regulated by European Parliament and the council 2004, concerning Communities statistics on information society (Eurostat 2009. *Methodological Manual for statistics on the Information Society*).

Table 1
Included and excluded industries in the Swedish Meadow Survey

Industries in business sector, *market producers and producers for own final use*[38]	**Nace classification**	**Percent Employees***
Agriculture, forestry, fishing	1-3	2,3
Mining and quarrying	5-9	0,3
Manufacturing	10-33	20,7
Electricity, gas, water supply, waste collection	35-39	1,2
Construction	41-43	9
Wholesale trade, except motor vehicles	46	6,4
Wholesale , retail trade, repair motor vehicles	45, 47	10,8
Transportation and storage	49-53	7,4
Accommodation and food service	55-56	4,0
Information and communication	58-63	5,5
Finance and insurance	64-66	3,0
Real estate, except advertising, other professional activities, veterinary	68-75	10
Administrative and support service	77-82	6,5
Education	85	2,5
Human health	86-88	4,7
Arts	90-93	0,8
Other service	94-97	2,0

Note: *The percentage of employees per industry in business sector included in the selection frame, calculated as the average number of employees per industry or group of industry divided with the average number of all employees in business sector, November 2008. The industries are defined according to Swedish Standard Industrial Classification, Nace 2007, European Classification of Economic Activities, NACE, Rev 2. Industries in business sector is defined according to the overall definition of business sector in National accounts GDP and FDB se also footnote 29, and matched with data in the LISA-database, se footnote 38. The marked business industries (in pink) are included in the Meadow selection frame.

Table 1 above presents the specific industries that are included or excluded according to the Swedish Standard Industrial Classification in combination with the definition of activities that are included in the business sector, primarily based on the overall

[38] Firms and other organisations in the business sector are defined by National accounts (GDP) and the European system of accounting (ESA) and on definitions in The Swedish Business Register (FDB). These are matched with information in the LISA-database of each organisations sector code (SektorKod). All organisations on the business market are included: 11 = Statlig förvaltning; 12 = Statliga affärsverk¸13 = Primärkommunal förvaltning; 14 = Landsting; 15 = Övriga offentliga institutioner; 21 = Aktiebolag, ej offentligt ägda; 22 = Övriga företag, ej offentligt ägda; 23 = Statligt ägda företag och organisationer; 24 = Kommunalt ägda företag och organisationer.

definitions of these activities in the National accounts GDP. The table shows that several service industries are excluded from the selection frame, mainly because they are excluded from the CIS Survey, and some of them are also excluded from the ICT Survey. The industries that are included represent about 55 percent of all employees working in the business sector, i.e. the market producers and producers for own final use in Sweden 2008.

There are assumptions concerning innovations and technologies in the different industries. Industries that are more likely assumed to use advanced technologies are included (see footnote 37). Firms in industries that are within manufacturing are more likely to be using advanced technologies, due to their products and production techniques. This is not assumed among service industries. Earlier studies in Sweden during the 1990s showed that the incidence of work organisation and competence development in the industries that are excluded here can be, but not necessarily would be, lower than in the included industries.

To fully describe working life in Sweden, all industries in the entire business sector and the public sector should be included in the future. If the expansion of the Meadow Survey has to go step by step, the next step should at least include all business industries. The Meadow Survey, its stakeholders and users, would gain from this.

Response rate for different size and industry groups

The 1 395 firms that constitute the selection frame for the Swedish Meadow are all included in the calculation of the response rate. Usually the over coverage is not included, but here it is because the rate is compared with the response rate of the CIS and ICT Survey where the over coverage is not withdrawn. This lowers the response rate by one percent in Meadow, but only marginally in the other two surveys.

Table 2
Response rate in CIS, ICT and Meadow

	CIS	ICT	Meadow tot	Production of: goods	services
10-49 employees	83	85			
15-49 employees			67	68	67
50-249 employees	91	86	66	63	69
250+ employees	89	82	58	65	46
Tot	85	84	63 (64)[(39)]	65	61

Note: Business classification according to Swedish Standard Industrial Classification, is based on European Classification of Economic Activities, NACE, Rev 2. Here they are aggregated in production of goods or service according to European System of Accounting, ESA. The over coverage is about 2-3 firms in CIS and ICT respectively, in Meadow it is 21 firms. The source of the overall response rate for the CIS Survey (see footnote 36), and for sizes, Sandra Dovärn, Statistics Sweden Department for Economic Statistics (Investments, R&D, ICT). The overall response rate and sizes for ICT-Survey (see footnote 37). The overall response rate for the Swedish Meadow Survey (see footnote 34). The calculations of response rates for sizes have been done by Rönnlund R, MSc student/MSc candidate, trainee at Statistics Sweden summer 2010.

As shown in table 2 in the last row, the overall response rate for the Swedish Meadow Surveys is 63 percent. The two EU-regulated and mandatory surveys CIS and ICT are higher and about equally high, 85 and 84 percent respectively. The response rate for Meadow is roughly 20 percent lower. This is a good result considering that Meadow is piggy-backing two surveys that are EU-regulated and mandatory, while Meadow is not. The Meadow Survey has been launched for the first time and it was performed after the two other surveys; Meadow was the third survey in a row submitted to the same firms. The other surveys' higher rates are probably also the result of several reminders to reach high rates. It is possible to conclude that some of the firms are rather content that they completed the two earlier surveys. Since Meadow is collected for the first time it is also possible that it still needs some adjustments to work even better in the future.

Table 2 also shows that the response rate in the Meadow Survey is rather similar in the different group of firms according to the two types of production and sizes, except for the large firms in services. For both the other surveys, action has been taken to obtain a high

[39] If the over coverage is withdrawn in Meadow the response rate is one percent higher, 64 percent.

rate for large firms[40]. The information from the collection of the Meadow Survey has presented that it was more problematic to replace the executive director if needed as a respondent in the survey in the largest firms (see footnote 33). This can help to explain the lower response rate for larger service firms in the Meadow Survey.

The response rate for different industries is not presented in a table but it is calculated. The response rate across industries fluctuates but can still be considered as rather similar. The rate is calculated at the industry group level since the selection frame is group level and it constitutes the relative chance for each industry to participate in the survey. The response rate for each group of industries is about 60 percent or above in Meadow. Compared to the two mandatory surveys the response rates fluctuate the same way. In other words, the industry group in Meadow that has the highest response rate is the same group of industries that has the highest rate in both CIS and ICT. In this case the particularly group of industries are in production of good and more precisely in manufacturing[41]. This also indicates that the lower response rate for large firms in Meadow is spread across the business sector, even though it is stated that the response rate for large service firms are lower than in production of goods.

Result from the non-response analysis

A non response analysis of the Swedish Meadow Survey has been conducted with help of economic register data and some of the data from CIS and ICT. Differences between the responding and non responding firms are obtained by calculating the means of the different variables. For 1 197 firms register data were available, divided into firms that responded and firms that did not respond the Swedish Meadow Survey. The result shows no significant difference between the responding and non responding firms, see parallel paper.[42]

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[40] According to the staff at Statistics Sweden, the Department for Economic Statistics (Investments, R&D, ICT).

[41] It contains the industries: Paper (Nace 17), Petroleum (Nace 19), Chemical products (Nace 20), Mineral products (Nace 23), Basic metals (Nace 34).

[42] Statistics Sweden, 2010. Productivity Yearbook 2010. Omanovic L, Statistics Sweden, and Aksberg M, Stockholm University BSc Mathematical Statistics. *Quality of data in the Swedish Meadow Survey*.

The ICT survey excludes some business industries but it is mainly the CIS survey that excludes several industries. Because of this the non-response analysis does not cover all differences across industries in the Swedish business sector.

Concluding remarks on the organisation of the survey

The technique to use the CIS and ICT survey as the selection frame makes it possible to match data between three surveys, including the Swedish Meadow survey and to reduce the questions in the Meadow Survey. The three surveys cover in principle all themes of questions in the Meadow Guidelines and can include several other register data with high quality, validity and reliability, at a low cost. Even though the response rate is about 20 percent lower than in the two other surveys that it is piggy-backing, it is reasonably high. The reason it is lower is that it has been launched for the first time and it is not EU-regulated and mandatory, and it was performed after the two other surveys. The non response analysis conducted with help of economic register data and some of the data from CIS and ICT shows no significant difference between the responding and non responding firms. The only known drawback with piggy-backing the two other surveys is that since they exclude several industries, the working life in Sweden will not be fully described, so analysis based on this survey cannot say anything about the excluded industries. All industries in the entire business sector and the public sector should be included in the future, at least stepwise, first of all business industries.

Frame of reference

The theoretical background to the measurement used is the EU Meadow project is described in three reports, two meta-studies: The Grid Report and The Multi-Level Theoretical Framework. The overall result is the Meadow Guideline. Here, in this paper I also specifically refer to the two Swedish Nutek surveys during the 1990s, which are included in the background studies in the EU Meadow project. The two Nutek reports are: Towards Flexible Organisations (Nutek project Flex-1); and Enterprises in Transition, Learning Strategies for Increased Competitiveness (Nutek project Flex-2); and Flexibility Matters - Flexible Enterprises in the Nordic Countries (Nutek project Nordflex).

The Meadow Guideline, to capture skills develops in the firm

The key question in the Meadow Guideline[43] is described as a growing consensus that knowledge in form of skills develops on all levels of the firm has become of increasing importance. Therefore one can conclude that the overall object in the guideline is to catch skills development in the firm.

The EU project was organised so that it studied questions and good results from earlier surveys that aimed to pick out the best questions to the guideline. Surveys included were two from USA, one from Canada, one from the European Union, and the rest from different member states in Europe including two from Sweden. The 21 surveys are summarised in the Grid Report[44]. The aim of this meta-study was to map existing quantitative data sources of National and European statistical system on employer and employee level and to present the state of the art in surveys on organisational change. The conclusion in the report is that many of the same questions and indicators were found in different surveys, even though the designers of the surveys build upon quite different theoretical traditions.

The guideline and the two questionnaires are the main concrete result of the Meadow background work. Further, the examination of the 21 surveys did indentify underlying theoretical perspectives. These are presented in a parallel report to the Grid Report and presented further on in this paper, Meadow Multi-Level Theoretical Framework, see also footnote 45.

The Meadow Guideline themes that is used

The result of all background studies in the EU Meadow project is concluded in the Meadow Guideline, that the Swedish Meadow Survey is mainly based on. The Swedish survey includes all themes in the proposed guideline, but the technique in the collection of

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[43] Meadow Consortium, 2010. *The MEADOW Guideline*. http://www.meadow-project.eu/index.php?/Atricle-du-cite/Guidelines.html. Proposal a framework for collecting and interpreting internationally harmonised data on organisational change and its economic and social impacts for private and public sector organisations.

[44] Meadow Consortium, 2010. Meadow Grid report, 2010. State of the art in surveys on organisational change, co-ordinator is Professor Peter Nielsen, Aalborg University. http://www.meadow-project.eu/index.php?/Atricle-du-cite/Guidelines.html.

some of the Swedish data is to use the CIS and ICT surveys and register data, as described above. The Swedish Meadow Survey covers in principle all themes of questions in the Meadow Guidelines and several other register data with high quality. Since all the Swedish Meadow data also can be matched with individual and firm register data, some questions in the Meadow guideline have been excluded in the actual new collection of data 2010. This includes more or less all data about innovations and ICT and background data about the firm and the employees, as well as economic output data of the firm. The Swedish survey 2010 is presented with its themes, in table 3.

Table 3
Swedish Meadow Questionnaire 2010, included themes

Introduction about the firm and the respondent
A. Workforce characteristics
B. Organisational structure and change
1) Work practices
2) Management practices
3) Outsourcing and Collaboration
C. Human resources
D. Objectives and context of the firm.

The questionnaire includes several themes. Section A. Workforce characteristics, gives information about number of employees, type of working contracts, and features of the staff structure etc.

Section B, is divided into three parts: the first unit 1, Work practices; and part 2, Management practices, provide mainly information about firms work organisation and practices as well as the firm's structural learning. Information from the last part 3, Outsourcing and Collaboration, is not yet used. The plan is to use this information together with CIS and ICT data in a forthcoming paper studying the firm's link to its environment.

Information from Section C gives information about employees' individual learning.

Section D is not used even though some data are collected, since other individual and firm data are available and of good quality. The used measurements are presented further on in the paper.

Underlying theoretical perspectives in Meadow

Meadow Multi-Level Theoretical Framework[45] is a meta-study of underlying theories behind the examined 21 surveys, and a parallel report to the Grid Report.

The Meadow theory report lists an important result that there are two major difficulties with the method to establish the multilevel theoretical framework. The first is that there is '*a lack of well-developed cognitive foundations which limits theoretical cumulativeness*' in the knowledge management literature. The second is that the analysis of organisational change draws upon a multitude of disciplines: economics, management sciences, industrial relations, labour studies, ergonomics and work psychology. Several others such as cognitive science, education and learning theory could have been listed as well. The overall conclusion is that the outcomes of the broad theoretical meta-study may still contribute to theoretical insights, but the link between theory and data needs to be constructed ex post rather than be taken as something that has been structuring the original design of the survey.

The underlying theoretical perspectives are summarised here, basically in the same way as they are presented in the report. The theories are divided into three levels: socioeconomic system level, organisational level and the individual level. The presentation is rather straightforward, and it includes some references to basic research. It is almost inevitable that the summary is coloured by my insights in the theory as an economist.

The socioeconomic system level

The system level includes theories concerning overall processes such as the society's organisation of higher education and research, technology shifts and markets. But it also includes theories about product and process innovations in a firm. The Meadow framework is focusing on overall systems but to some extent also includes some theories of how organisations interact in these systems. It is stated in Meadow that indicators of organisational change are often parallel to indicators of product, process and market innovation etc.

[45] Meadow Consortium, 2010. Meadow Multi-Level Theoretical Framework, 2010. Theoretical key elements and interactions reflected in data collection on organisational change, innovation and work conditions, co-ordinator is Professor Peter Nielsen, Aalborg University. http://www.meadow-project.eu/index.php?/Atricle-du-cite/Guidelines.html.

Theories of innovation, especially if they are based on endogenously driven processes of change, are included in theories concerning socioeconomic system level. These concern the overall economic system level and systems within and between firms (Schumpeter 1934, 1959, 1989). Innovations are seen as changes of products, processes, markets, inputs, and organisational innovations. An underlying conclusion is that all of these aspects are parallel or I would even argue that they often can be seen as intertwined. It is argued that innovation systems also include selection of firms, birth and deaths, entrepreneurship and small firms and larger often oligopolistic firms, but these aspects is not equally explored in the framework.

A rather traditional perspective on innovation on the system level is the change in major techno-economic paradigms, emerging in cycles of about 50 years (Perez 1983, Freeman and Perez 1988, Freeman 1991). These technological changes are often related to production technology and industrial manufacturing organisations with a long delay in impact on productivity and growth.

Other perspectives are evolutionary-oriented theories (Perez 2004) that include inertia or gradual evolutionary changes or the interaction between organisations and their environment. Compared to Schumpeter these perspectives are not linear processes. Instead they focus on co-evolution between technology and organisation, between drivers and impacts (Lundwall 2007). The assumption of interaction and feedback are seen as crucial for innovation performance of the firm (Rothwell 1977, Pavitt 1984). Strong connection and interaction among divisions as well as with customers and suppliers are successful characteristics for innovations.

The last decade's complementary innovation system within national systems has come more in focus. There are regional and sectoral systems as well as technological and competence-building systems. Theories about the learning economy are related to these complementary innovation system approaches. They address both public learning systems and learning activities within work, including work organisation and systems for learning at work. These theories also intertwine policies of lifelong learning and concepts such as "flexicurity" and numerical flexibility. Industrial relations and labour market organisations as well as systems of labour insurance are addressed. New public management and human service organisations are also discussed. Several aspects have been brought into attention but not equally explored as changes of products and technology.

Organisational level

The most important conclusion in the Meadow theoretical framework concerning organisational level is about the upcoming of HRM theory, human resource management (Fombrun et al 1984, Bee et al. 1984). Earlier perspectives on employees and management have been narrower, and employees were more or less only looked upon as production costs, and management of employees has mostly been seen as control of production. However, employees today are increasingly looked upon as the most important resource in the firm. The role of management is broader, and includes allocation of all important resources, including employees, to achieve the business goal.

When it comes to theories about changes on the organisational level, the focus is on management of knowledge and continuous learning in combination with planning of personnel and the business strategy. Some models emphasise the strategic and rational approach to management resources, while others emphasise the utilisation and development of the employees, based on consensus and commitment among employer and employees. The aim is to seek a competitive advantage. (Storey 1992, 1995).

One strategy is alignment between business strategies and human resources strategy. Another strategy is to build loyalty, while a third is to emphasise all personal capabilities and not only formal skill boundaries.

The organisational design is critical in the HRM theory and it constitutes a frame that promotes and develops the employees. Therefore changes towards decentralisation are seen as crucial. Team-based jobs, self governing for planning and control and quality improvement are basic features (Huselid et al 1996). Job rotation and cross functional networks are also seen as promoting continuous learning.

HRM is also merged with theories about Industrial Relations in Employment Relation Theories. The challenges are: 1) meeting the up-skilling and rapid change in new information and communication technology, 2) shift from traditional industrial relations towards HRM in local firm bargaining, 3) rapid development of temporary work contracts, self employment, part-time work, 4) outsourcing and downsizing (Gallie 1998).

One of the first concepts to meet these new demands were the theories of the Flexible Firm (Atkinson 1985). When the concept was first introduced over twenty years ago, it divided work and the workforce into core and peripheral. The core considered horizontal flexibility strategies in the firm, Atkinson called it functional flexibility. For example, he included job rotation as a functional flexibility. Strategies to meet short time fluctuations on the market were called numerical flexibility. The two perspectives on flexibility were assumed to interact with different segments in the labour market. The labour market was seen as dual. Qualified tasks and highly educated people were related to the core, and the rest more or less related to peripheral tasks. Financial flexibility was added and associated with wage flexibility, and at that time related to numerical flexibility.

The term work system is, in parallel with concepts of learning organisations, interrelated to specific work practices. Work organisations mainly refer to division of tasks and employees, while the execution of these tasks is referred to as work practices (MacDuffie 1995). There are synergy effects on performance when they are adopted together (Delery 1997). A concept that takes this interrelated perspective further is "High Performance Work System". It also includes high involvement of employees, sometimes other organisations. It is yet to prove its impact on performance (Pil & MacDuffie 1996).

Organisations that need to meet multi-complex environments can gain by being process-oriented. Each part of the organisation, or sub parts, meets the demand of new technologies, customers, products, markets etc. with its own precondition. The different units of the organisation are organised after its own specific circumstances. Feed-back and feed-forward, often horizontal regulations, are instruments for control. Different teams/units discuss directly with each other. The management's role is to create, promote and monitor self-management teams.

Lean production is not a concept so far from the process-oriented. The first definition was "precisely specify value by specific product, identify the value stream for each product, make value flow without interruptions, let the customer pull value from the producer, and pursue perfection" (Womack and Jones 2003). The practical use is described as cost reduction, empowerment, value chain orientation, customer focus and product innovation. The model is often referred to as the Toyota-model. Various forms of the model have been implemented and followed up with varying results.

Teamwork, which seems to be a straightforward practice, is not described as a uniform concept, and follow ups of the benefit of various forms of teams show various results. They have one feature in common: all forms of teams have increased (Huys 2007). Much of the focus is on the structure of the teamwork: tasks, the degree of autonomy, the interdependency in the team. Maturity and diversity of the team members can be added (Delarue and Savelsbergh 2005).

Many economists have a resource-based view of the firm when it comes to their organisation. The firm is seen as successful if it possesses a superior set of resources or is able to explore its resources more efficiently than its competitors (Billerbeck 2003, Burr 2004). The perspective aims to explain heterogeneity in firm's economic performance (Helfat/Peteraf 2003, Gersch et al. 2005). The firm's resources include physical and tangible resources as well as intangible and dynamic capabilities (Teece et al 1997, Barney 1991). Dynamic capabilities are seen as the firm's capability to learn routines and routines for learning (Eisenhard and Martin 2000).

Knowledge management is defined as an intentional and systematic process of acquiring, sharing and using knowledge to enhance learning and performance in organisations (OECD 2003). Knowledge management deals with knowledge transfer between different types of knowledge: explicit, not explicit, tangible, intangible, tacit, and individuals/organisations (Nonaka and Takuechi 1995). Managing diversity is one way to describe it, gender is an important field in this research and other aspects of formal and informal processes in the organisation (Härenstam and Bejerot 2007).

Culture has had a prominent position in management theory, like formal cultures and management strategies versus subcultures in a firm (Schein 1988) but it is argued that it has diminished in recent decades. Many researchers have been involved in quality approaches of the work organisation. A starting point can be the discussion of quality in the Japanese production during the 1950s (Deming 1986) including the Total Quality Management TQM-model, described by many researchers and summarised as the integration of all functions and processes within an organisation to achieve continuous improvement of the quality of goods and services (Ross 1994).

Organisational innovation is specifically described in the Meadow theoretical framework as dependent on several different approaches. I summarise a few of them. The first approach is to see organisational innovations as a basically intentional process of breaking down regular patterns of behaviour to create new patterns that become institutional (Lewin 1951). A modern approach is described as when members of the organisation are constantly changing (Kant et al 1992). The perspective is seen as incremental, which means that the organisation can look stable on the surface but is built on instability.

There is of course opposition to the second approach that puts forth the same basic criticism when it comes to a broad definition of innovations concerning products and markets etc. The opposition defines organisational innovations as the development and implementation of new organisational structures and processes that offer customers more flexibility and efficiency (Goffin and Szwejczewski 2002, Armbruster et al 2006). This approach aims to approve business performance. Another business perspective on this is the definition that organisational innovations are the discrepancies between what the organisation could do and what it actually does, i.e. the performance gap. Maybe a complementary approach is that this cannot take place without individual and organisational learning (Gjerding 1996).

The role of management in organisational innovations is focusing on ambiguity. One perspective is described as speeding up processes and, as equally important, at some point slowing down changes on a redirected path. Another is described as a dialectal process, based on a dialogue between two or more parts of the organisation. The different parts may hold differing views, yet wish to pursue truth by seeking agreement with one another, where the innovation is involving combination of different goals and methods simultaneously. If all are involved in changes, the innovation is very complex. But if only some are involved, the innovation can be easier but there can be ramifications for the coherence of the organisation. Coherence is an approach in itself. Finally, approaches of innovation processes is also focusing on how speeding up and slowing down take place. Are they linear or occurring simultaneously? The hypothesis says they do when including feedback.

Individual level

Theories on the individual level specifically include impacts of work organisation and competence development on individuals. It seems to include both the individual's own view of these aspects and a system perspective on the employees, in contrast to the employers view on the organisation as such. The employer's perspective of the organisation and its employees is as I see it covered in the section above. Still, the individual level is not obviously focusing on the individuals perspectives on different matters. Even though the EU project has proposed a linked survey between employer and employees, one would assume that the individual level would be matching the employee survey to a great extent. The current project in Statistics Sweden is only collecting information from employers about the employees. But complementary register information about the employees can be used. In the future Statistics Sweden proposes that forthcoming surveys are linked between employers and employees. Anyhow, theories concerning individuals are presented in the Meadow framework.

The concept of competence development is used as a way to describe almost all activities crucial for the society, organisation and the individual. In the framework of Meadow it is narrowed down to three important perspectives. One is the generic competence, the ability of the reader to understand the implied system of codes, i.e. for example a language. The other perspective is situated competence, i.e. the context for example in a school or in a job situation. The third is collective competence, closely related to job situation, organisational culture and work practices.

The change from lifelong employment to a flexible labour market and different working conditions and the importance of continuous learning are much in focus in this part of the framework and reflected on. The changes in the labour market in recent decades are described as profound both in terms of work load, stress and new work practices, the new and broad use of information technologies etc. (Paoliand Merllié 2001). Discussions about stress and health issues are in focus.

It is argued that there are systematic links between the forms of work organisation adopted and the quality of jobs including working conditions and health and safety (Valery, Lorenz, Cartron, Csizmadia, Illéssy, Gollac, Makó 2008). At the same time it is argued that it is the combination of high demands and low control that is detrimental to health (Härenstam, Bejerot 2007).

Another point is that organisational change as such is identified as hazardous to health (Bordia et al 2004, Kaminski 2001, Kivimäki et al 2001). Research on temporary contracts, job insecurity and nonstandard job arrangements are seen as still limited. Some studies show a negative effect on the employee's health (Benach 2004, Benavides et al 2005, Virtanen et al 2002) while others find the opposite relationship with health (Bardasi and Francesconi 2004, Virtanen et al 2003). The conclusion is that the results are due to the circumstances people accept nonstandard work, i.e. if there is a lack of opportunities. Other results show that people with poorer health conditions from the beginning often have nonstandard job arrangements.

These perspectives are important in the discussion of how to organise the working life and labour market so that it includes all people that have at least some capability to work. Motivation theories, reward and compensation systems theories, including bargaining theories and labour (industrial) relations, are also discussed.

Two Swedish surveys in the 1990s

Two Swedish surveys have contributed with questions and an economic background to the Meadow Guidelines; they have been conducted by Swedish National Board for Industrial and Technical Development, Nutek. The main report of these surveys shortly describe how they look upon the economy, its conditions and presumption as a background to their specific measurements of work organisation and competence development. The background knowledge of the economy has also influenced the measurements in the overall Statistics Sweden project, this and parallel papers. To better understand the measurements used in this paper, the background and result of the two surveys will be shortly presented.

To start with, it is worth mentioning that both of the two earlier Swedish surveys took place after the deep economical crisis in the Swedish economy in the early 1990s. The first[46] survey was conducted a couple of years after the crisis, in 1995, and almost at the same time as the manufacturing industry had bounced back to

[46] Hans-Olof Hagén, project manager of the present Statistics Sweden-project, was the project manager of the first Nutek survey 1995-1996, Annette Nylund participated as co-project leader.

the earlier performance level. The second[47] survey was conducted some years later, 1998, and at this time almost the entire Swedish economy was more or less back in balance. It was before the next crisis in the Swedish economy that took part in the first couple of years in the new millennium, i.e. when the IT-bubble burst in Sweden.

Both Nutek surveys describe the decades in the Swedish economy before the 1990s as characterised by low productivity despite a constant high pressure from the outside world. From the mid-1990s the Swedish economy made positive progress in comparison with other OECD countries, and growth in Sweden was appreciably higher.

Based on the first Nutek survey several reports were published by Nutek. In the first one, where the main results were published in 1996[48], the economy is described as changing from large oil-tankers to a fleet of smaller and faster boats, moving in the same course, according to new technology and market demands. The economy during the industrial era, after the two world wars and before the oil crisis in 1973, was characterised by a rapidly expanding growth. In that era predictions about the future were rather easy and the steady growth fed larger firms, which often had long term planning departments and long term plans. But the smooth broad growth changed to a rockier pathway. In this new more unstable environment, flexibility and continuous learning became a must.

Therefore the first Nutek survey specifically included measurements of both numerical and functional flexibility. Functional flexibility mostly concerned work organisations, and who in the hierarchy of the organisation carried out different kinds of tasks. Another important aspect was the employees' competence development at work. An index including these two aspects was created, i.e. information on the degree of decentralised task and if the everyday/normal work contain elements of organised skills development. The top quartile of those work places that were

[47] Hans-Olof Hagén was the project manager and Annette Nylund the co-project manager in the second Nutek survey 1997-1999, which also included some new publications based on the first survey. When Hans-Olof Hagén left Nutek Annette Nylund became the project manager for the last year of the project 1999-2001.

[48] Swedish National Board for Industrial and Technical Development, Nutek, 1996. *Towards Flexible Organisations*, Nutek B1996:6.

highest ranked was selected and compared to the rest of the work places.

Other preconditions also played a part in the construction of measurements, such as the argument that some industries did have difficulties attracting and keeping young employees. At the same time employment agencies that hired out temporary employees to firms and other work places started to grow. Short time contract workers seemed to increase. Therefore different kinds of measurements of numerical flexibility were included.

The second Nutek survey conducted in 1998 was a follow up on the first survey, but even so it elaborated on the measurements a bit further. For instance, in the main publication (2000[49], 2001[50]) there is a greater awareness of the distinction between the individual's competence development at work and the firm's ambition to create structural capital. The distinctions are following some principles of human resource management that include "selection and recruitment of personnel; design of work organisation, job description and remuneration systems, job evaluation, and various forms of personnel training/development"[51] The way to collect information about these issues is more or less the same in the two surveys, but the creation of indexes based on the information differs. In the main report, based on the second survey, the index that measures a decentralised work organisation is also taking into account how many of the tasks that are relevant for each firm, and the scale was based on the relevant number of tasks. An index was made based on this information that goes from 0 to 100 percent. The first survey did not consider that all tasks are not relevant for all firms. The second change in the measurement of decentralised work organisation is that the index of decentralisation is not combined with other measurements, it stands out by itself. In the first main report it was combined with information about daily learning.

Daily learning at work is still an important measurement in the second Nutek survey, but in the main report it is based on an index

[49] Swedish National Board for Industrial and Technical Development, Nutek, 2000. *Företag i förändring, Lärandestrategier för ökad konkurrenskraft*. Info nr 052-2000. See footnote 50.

[50] The Swedish Growth Policy Studies, ITPS, 2001. *Enterprises in Transition. Learning Strategies For Increased Competitiveness*, A2001:001. See footnote 49.

[51] Ellström P-E, 1991. Kompetens, utbildning och lärande i arbetslivet – problem, begrepp och teoretiska perspektiv.

that is combined with other measurements of individual learning and not with information if the tasks are decentralised. The question about if everyday/normal work contain elements of organised skills development is combined with two other questions. One question about if the work place has development plans for the employees and another question about the proportion of employees that participated in training/courses that were wholly or partly paid by the employer the specific year. The index of these three questions results in a scale that goes from 0 to 3, depending on how many of the activities the work place uses, from none up to a top of three.

There are other differences between the two surveys and their main reports that are worth mentioning, even if they are not elaborated further in this paper. One is the argument that measurements of external factors[52] such as the market and changes in the market, cooperation and interaction with other firms and other parties have to be included. This is because these activities are assumed to be of great importance for competence development and their importance is assumed to have increased. The measurement of these aspects is more elaborated in the second Nutek survey and a bit further analysed than in the first report. Another difference between them is that the first survey included measurements of information technology, IT, that were focussed on production technology. These aspects were partly included in the second survey and elaborated. But the second survey also included new measurements of information communication technology, ICT. These two aspects, cooperation with other parties and ICT, are further elaborated in parallel and forthcoming paper.

The data from Flex-1 was combined with developed perspectives of how to measure human resource management in Flex-2 and a third study was performed. It also contains data from Finland, Norway and Denmark, see Flexibility Matters.[53]

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[52] Teece, 1999. The Design Issue for innovative Firms: Bureaucracy, Incentives and Industrial Structural. Article in *The Dynamic firm – the role of technology, strategy, organisation and regions, (eds) Chandler, Hagström, Sölvell.*

[53] Swedish National Board for Industrial and Technical Development, Nutek; and Swedish Minister for Industry, Employment and Communications; and International Business Economics Department of Development and Planning, Aalborg University; and Ministry of Labour in Finland; Institute for Social Research (ISF) in Norway, 1999. *Flexibility Matters - Flexible Enterprises in the Nordic Countries*, B 1999:7.

A not yet mentioned parallel paper is studying the included work places in the Flex-2 survey over a period of ten years. The objective is to study if there are any long term effects of used work organisation and competence development on productivity.[54]

Concluding remarks on reference

The overall conclusion concerning the EU Meadow project and its background reports is that they considerably increase the validity and reliability of the EU Meadow guideline. Since the Swedish survey is based on the guideline it also increases the quality in the Swedish survey.

The underlying theories are presented in a background report on the EU Meadow website, see footnote 26. I have read the report with great interest. As mentioned the report provides an important quality aspect to the guideline, and it is one of the more recent overviews of theories in the area. Hopefully, and as far as I understand there is a chance that this background report will be further developed and published by some of the project members in the EU Meadow project[55].

Some reflection that might be useful in the further development of the report is that the division of theories, perspectives, in three levels might gain by a being differentiated from actors, and other kinds of institutional parts of the system. Interaction between the levels and different actors and institutions, according to theories might also be of interest to include.

For example, theories supporting studies of business organisations, i.e. firms, are probably in some sense more straightforward since the firm in a more intuitive way is separated from systems and individuals than for example public or households' own organisations. Of course almost everything is connected in some sense, but public organisations are more often integrated important parts of the system, and are often representing the government policy, at the same time as they are organisations as such. Many people work in them and it is important that their work organisation

[54] Statistics Sweden, 2010. Productivity Yearbook 2010. Wallén H, MSc. Candidate at Royal Institute of Technology, KTH, School of Architecture and the Built Environment, Departments of Transport and Economics, Division of Economics. *Organisation and Long-term Firm Development*.

[55] According to professor Peter Nielsen, Aalborg Universitet, team leader for the Danish research group in Meadow.

is efficient. A public organisation that is not acting on the market but in the public sector is more obviously a part of both the system levels and the organisational level, at the same time. It is possible to 'sense' these aspects in the EU report and they can be further developed. According to theories on the individual level, the interpretation is that they are based on system perspectives on individuals or group of individuals. Several of the theories on individuals that are included are based on theories about systems and organisations institutions connected to systems.

According to the Meadows theoretical background and its three levels of theories, the presentation of the three levels are not distinctively seen as intertwined with each other, even though it is mentioned that organisational innovations and systems are described as parallel. The focus is neither on interaction between different organisations nor employees in different organisations. Focus is rather much on organisations as such and employees in the organisations. Further the employees are seen as proactive and learning, at the same time the theoretical perspectives on the individual level are focusing on more negative impacts on employees.

Still, it is tempting to test some of the more advanced theoretical assumptions about organisational innovation with the help of the new data at once. For instance, the theories about organisational innovations based on breaking down and building up new patterns, but this kind of analysis will probably demand data from several years of collection. Another intriguing hypothesis to test is the performance gap and the resource-based view of the organisations. But as I see it, knowledge building will probably gain from a stepwise approach towards both theory and data. Therefore, this first paper wisely uses theories as well as the data exploratively and tentatively. The measurements do not take a stand in any of the concepts, they simply measure the incidences of several of them. Therefore broad indicators are created and used in this and the other parallel papers in the project. The indicators are presented further on. Still, forthcoming analyses include building more complex models and studying its relationship with the firm's environment. There will also be possibilities to relate the model to the firm's economic performance and the employee's position on the labour market.

As mentioned above, the common frame between the three Swedish surveys, CIS, ICT and Meadow creates greater possibilities to make analyses of intertwined perspectives between system level aspects, organisations and individuals. Several of the presented and traditional themes concerning innovations can be found in the CIS Survey, and some aspects can be found in the ICT Survey. These have been used in parallel papers to this one. The relationship between innovation and work organisations as well as competence development are analysed[56], and relations between ICT and work organisations and competence development[57]. Other parallel papers are analyses of differences between sexes[58] and differences in working conditions[59]. Forthcoming papers include further analyses of the relationship between the firm and its environment, and economic performance, as well as the employees' position on the labour market.

Four composite indicators

Theoretically it is possible to present all the data in the Swedish Meadow Survey but it is not so analytically meaningful. In the Statistics Sweden project measurements of work organisation and competence development are classified into four groups of indexes, here called four composite indicators. These four indicators are also used in parallel papers in the project. Authors of the different papers have contributed to the construction of and knowledge about the composite indicators in different ways. Even so, the construction of the indicators is mainly the result of decision by the management of the Statistics Sweden project. My intention here is to describe them and to use them as tentative measurements of work organisation and competence development. In other words, I use them in an explorative way. In my forthcoming papers I will use theory and availably data in a more profound way, both by study patterns of practices and specific models like the ideas about the firm's competence portfolio and its links to the firm's environment.

[56] Statistics Sweden, 2010. Productivity Yearbook 2010. Grünewald O, 2010, *Work Organisation Innovation and Productivity.*

[57] Statistics Sweden, 2010. Productivity Yearbook 2010. Lagerquist M, 2010, *ICT, Organisation and Productivity*.

[58] Ahlstrand C, 1010. *Work organisation and differences between sexes*.

[59] Statistics Sweden, 2010. Productivity Yearbook 2010. Hagén H-O, 2010. *Flex-3 a work in progress, and The impact of the working conditions.*

Why these indicators?

The choice of indicators is based on the fact that firms are acting in environments that change more and more every year. This means that firms' ability to adopt has become a necessity for their survival in the long run and their economic performance in the short run. Earlier I described that the growth path have become rocky, which was the case during the 1990s, and it has also been profound the last couple of years during the financial crisis that culminated in 2008. The repeatedly coming crises during the years has showed the firms the importance to be able to reduce cost very fast, even labour cost with short notice. Therefore indicators of numerical flexibility are still included among the composite indicators in the present survey and analyse. They were also included in the Nutek studies during the 1990s. This kind of indicator is not necessarily assumed to be positively correlated with productivity, since the use can fluctuate with the labour market and the rise and fall of the economy. The features are still of importance to study. Some background information shows that the Swedish labour market has a relatively high proportion of fixed-term contracts: about 16 percent of all employed. Only five other countries in Europe have higher proportions. Sweden also has the second highest proportion of part time workers: almost 27 percent of all employed and about 5 percent self-employed. Measured over a period of about ten years the proportion has changed marginally.[60]

Flexibility in terms of rotation between different tasks within the firm was partly in focus in the earlier studies, and is included among the present indicators. It can be seen as an indicator of numerical flexibility since it alters the total hours worked from one task to another in a department and sometimes between different departments in the firm. It can also be seen as an indicator of functional flexibility since it indicates that the employees have competence to work with several tasks within the firm.

The need for flexibility also forces the firm to develop new ways to meet customers' demands on short notice. Decentralised work organisations in combination with customer focus can create more and broader possibilities to pick up early signals, taking advantage of new opportunities and act to different threats. This way the firm

[60] European Commission, 2009. Directorate-General for Employment, Social Affairs and Equal Opportunities. *Employment in Europe 2009.* ISSN 1016-5444.

must understand that the employees have become a more vital resource in the planning of the work. The management is therefore broadened and includes allocation of all important resources, including employees, to achieve the business goal. Indicators measuring some features of knowledge management, work organisation and practices, and self-management teams, also in combination with product quality and customer focus are therefore included in the composite indicators. The two earlier Nutek studies showed significantly positive correlations between decentralised work organisations and productivity. Since the same kind of information is collected in the Swedish Meadow Survey it will be possible to create a similar indicator and to also compare the incidences.

Learning aspects in the firm are included in the measurements, both individuals' learning and if the firm is building on structural capital. The assumption is that learning also contributes to the flexibility of the employees and the firm, since learning helps the adaption of a rapidly changing environment. This gives the firm better chances to survive and increase productivity and profitability, and hopefully it helps the employees to keep their job. Since there is a greater awareness of the distinction between the individual's learning and the firm's ambition to create structural capital, measurements of learning are divided into two indicators. Learning in the daily work is one approach that in the earlier Nutek studies showed to be significantly correlated with productivity and profit. Building structural capital in the firm was not specifically analysed in the earlier studies but has been argued to be of great importance for growth and productivity. There seems to be some good information in the Meadow to build indicators of both individual and structural learning.

In summary, the objective is to use all relevant information in the Swedish Meadow Survey to study work organisation and competence development in the Swedish business sector. There is also an ambition to follow up the two earlier Nutek studies concerning these aspects in the Swedish economy. Four composite indicators based on these features are constructed to capture the firm's use of human resource management strategies. Both the employers' and the employees' perspectives are important, when it comes to the firm's need of alignment of business strategies and customer focus with the employee's capabilities and continuously learning. Indirectly it is stated that responsibilities and authority go hand in hand, to create better work conditions and to meet customers. Views of the employees are not measured in this first Swedish Meadow Survey, but these firm features can be related to register data of the employee's background and position on the labour market.

The construction of the indicators

The four composite indicators include information from the Swedish Meadow Survey that is based on the Meadow guideline, which in turn also includes questions from the Nutek surveys. The Swedish Meadow Survey also includes one question from the Nutek survey that is not included in Meadow guideline, more on this further in the paper.

First some technical features. The questions in the survey are constructed and organised in different ways. Sometime the answer can be a simple YES or NO, while other questions have several options in their answers or almost infinite options since they are numerical. Therefore the amount of optional answers in every question has been standardised so the construction of the question will not affect the importance of one question compared with another question.

Further, all questions in each indicator sum up to 1, which means that each firm can have a value of each index between 0 and 1. If a firm has the highest value in all four indicators the value will be 4. All questions have been given a specific weight according to assumptions described below in the presentation of each indicator. Most of the questions have the same weight which means that they are seen as equally important. If they have a higher or lower weight they are assumed to be of less importance compared to the other questions in the index. The robustness of these specific weights has been tested to see if the same firm will be highest ranked in the index if the weights are altered, in its own business industry group. The test shows that the result is robust. This is also one reason for to create broad indicators, they often are more stable. For a presentation of the test and its result see the parallel paper, footnote 42.

All questions that are included in the four indexes are presented below. In case a question is depending on another question, all needed information has been included in the presentation of the question.

Individual learning

The sub-questions presented in table 4 define the indicator *Individual learning*. All questions except for one have the same weight in the indicator. The specific question that has a higher weight is *"96. Is competence development part of the normal every-day work, Yes or No?"* This question is assumed to be of more importance than the other questions, and the assumption is based on earlier results. This specific question has been used at least twice in analyses studying firm and employees performance, and is therefore known to be of importance. In the first Nutek study this question was the only used measurement of individual learning, in the second it was part of an index including three questions. The question was included in a Swedish cognitive test, with a good result, before it was used in the second Nutek survey 1998. Those firms and work places that answered that the daily work includes competence development have been found to have a significantly higher productivity rate than others. Therefore the question of daily learning has been given 2/3 of all the value of the indicator, in this new measurement of industries across business sector in Sweden 2010. In the table the weights are indicated in parentheses. At the same time the importance of this weight shall not be exaggerated, since the result is that the indicators are rather robust, as mentioned above.

Several questions were deleted in the final proposal of the EU Meadow Guideline for different reasons. The above mentioned question is not included in the final guideline because the cognitive test of the questions in the EU Meadow project found it to be to problematic to understand. This is the only question that is used in the Swedish Meadow Survey that was tested but not included in the final proposal of the EU Meadow Guideline.

Table 4
Individual learning

96.	Is competence development part of the normal every-day work, Yes or No? (2/3)
102.	What proportion of employees has received on-the-job training in the past 12 months? (1/12)
94.	Approximately what proportion of your employees has a performance appraisal or evaluation interview at least once a year? (1/12)
99.	What proportion of employees has been given paid time-off from their work to undertake training in the past 12 months? (1/12)
100.	What proportion of employees has been given non-paid time-off from their work to undertake training in the past 12 months? (1/12)

The index about individual learning is rather straightforward. It includes both formal and informal learning activities. The question about if the daily work can capture formal and informal learning, including tacit knowledge, can be described as not explicit learning and not explicit knowledge. It can also indicate perspectives like continuous learning at work, because it is daily. The index also includes information on whether the employees participate in other training and learning activities at the work place or elsewhere. This kind of training can be strategic investments in the future of the individuals, both in the firm and elsewhere. If employees participate in these kinds of learning activities it might also say something about the climate of learning in the firm. The index does not generally give specific information about whether the firm is trying to build competence that can be seen as structural, except for the question about performance appraisal or evaluation interview. This kind of evaluation meeting can give both parties information and can be used to build structural capital. Because it also can be an indication of structural learning it is also included in the index of structural learning. The question is marked in grey to indicate that it is included in two indicators.

To summarise, the indicator of individual learning indicates the understanding of the importance of continuous learning at work, both formal and informal learning, including tacit knowledge. The hypothesis is that the indicator is correlated with almost all the other indicators, and that it indicates a good climate for learning in the firm.

Structural learning

The sub-questions below in table 5 define the indicator called *structural learning*. Each question has been given a specific weight according to its assumption of importance compared to the other questions in the index. All questions in the index have the same weight, and are therefore assumed to be equally important. The reason is that there is no information in advance that one of this questions are of more or less importance, therefore they have the same weight.

Table 5. Structural learning

44.	What proportion of employees at this firm currently participates in groups that regularly meet to think about improvements that could be made within the workplace? (1/7)
94.	Approximately what proportion of your employees has a performance appraisal or evaluation interview at least once a year? (1/7)
53.	Does this firm monitor the quality of its production processes or service delivery? Yes or No.
57.	Do employees in this firm regularly up-date databases that document good work practices or lessons learned? Yes or No. (1/7)
59.	Does this firm monitor external ideas or technological developments for new or improved products, processes or services? Yes or No. (1/7)
61.	Does this firm monitor customer satisfaction though questionnaires, focus groups, analysis of complaints, or other methods? Yes or No. (1/7)
104.	How often do meetings between line managers or supervisors and all the workers for whom they are responsible take place? (1/7) a) Every day b) At least once a week c) At least once a month d) Less than once a month

All the questions about structural learning indicate if the firm is building knowledge, and several of them can be seen as indicators of investments in structural capital. It is also rather obvious that the indicator gives information about if the firm is working with quality and innovations concepts, and also if these are systematically organised. This latter aspect is seen as critical when it comes to long term quality issues. Some questions in the index also give structured information about products, processes and the customers. If this information is combined with information about if the work is decentralised and organised in teams, it can be used as an indicator of an awareness and structural approach to meet customer demand. Using new information technologies to build structural capital is seen as important; this information can specifically be found in the questions about databases and is also indicated in the question about monitoring external ideas or technological developments.

The question about meetings between line managers/supervisors and employees is in line with the question about performance appraisal or evaluation interviews. The latter one of these two is, as mentioned above, an indicator of both individual and structural learning. The dialogues captured in the two questions can be instruments to build structural capital as well as instruments to improve individual's skills. The question that is used in two indexes is marked in grey to indicate its use in two indicators.

In summary, the indicator structural learning provides information if the firm is building structural capital thru systematic work with quality and innovations, and strategies about customer satisfaction.

Numerical flexibility

The questions in table 6 define the indicator called *numerical flexibility*. Two questions have been weighted so that the value of the answer is less important compared to the other questions, they only have weights of 1/6 each. Rotation of tasks within the firm is one of these questions, the other is about part-time work, and both questions can be seen as flexibility within the firm even if they are not assumed to be closely related to each other. This means that the other questions concerning fixed and short term contracts are valued higher in the indicator. These later aspects are not necessarily assumed to be positively correlated with the other sub-questions in the indicator or with the other indicators.

Table 6
Numerical flexibility

51.	Are any of the employees at this firm trained to rotate tasks with other workers? The training could have taken place outside or within your firm. Yes or No. (1/6)
11.	What proportion of the employees at this firm has a temporary contract? This includes all employment contracts with an end date or for a defined period of time, even when the contract is for several years. (1/3)
14.	Please think of the total number of people working at this firm, including employees on your payroll and people contracted through an employment agency. What proportion of this total consists of people from an employment agency? (1/3)
12.	What proportion of the employees at this firm is part-time? 'Part-time' includes all working-time arrangements below the usual full time hours that apply at your firm. (1/6)

As can be interpreted and more or less obvious when reading the questions concerning numerical flexibility, they contain of two or three perspectives. The question about task rotation is an indication of flexibility within the firm. The other perspective is the traditional aspect about fixed and short term contracts, each captured in separate questions. A third perspective is the question about part-time work, since it is a way to change the total number of working hours within the firm but without new short term contracts. Because the survey is collecting information only in the business sector, and not in all industries, this latter concept is not as obvious as it is in the public sector and some service industries where part-time work is frequently used this way. Therefore it is a better chance that it can be an indicator of the employees' personal preferences or the preference decided in the family, and not by the firm. In that case, part-time employees can use more of their time after their own preferences or after the needs in their family. All three perspectives can include core as well as peripheral work and work force.

The index does not explicitly include information about what is called knowledge transformation and needs of continuous new knowledge from outside the firm. The use of consultants, often other than private employment agencies, is used as such indicators. It is assumed that knowledge in the absolute frontline often is available with help of these consultants or through the firm's cooperation with other organisations. At the same time the private employment agencies in Sweden have a high proportion of university educated employees; some figures from a few years ago show that the proportion of university educated in these private employment agencies was even higher than on average in the industry group that they belong to "*Office administrative, office support and other business support activities (Nace 82)*".[61] This figure is an indication that it cannot be excluded that there is an element of knowledge transformation in using private employment agencies.

To summarise, numerical flexibility provides information about work flexibility within the firm in terms of task rotation, and information about possible flexibility in terms of changes in the total amount of workforce with short notice. It might also indicate the use of an external workforce for knowledge transformation.

Decentralisation

The questions in table 7 define the fourth indicator, called *decentralisation*. The only question that has another weight than the others in the index, and that is assumed less important, is question number 26. *How many organisational levels are there in the firm?* The numbers of hierarchical levels are known to be related to the number of employees in the firm, and can therefore also be an indication of the firm's size. But there are also other arguments, see below.

[61] In Swedish the apostrophised industry often is called "Företagsnära tjänster". Se also HTF Utan de privata tjänstebranscherna stannar Sverige1 Privata tjänstebranschers bidrag till tillväxt och jobb.

Table 7
Decentralisation

26.	How many organisational levels are there in your firm, including the highest level (for example, senior management) and the lowest level (for example, production staff)? Number: ....(1/9)
32.	Who normally decides on the planning and execution of the daily work tasks of your non-managerial employees? (2/9)
a.	The employee undertaking the tasks or both employees and managers or supervisors
b.	Managers or work supervisors, or others
34.	Who is usually responsible for quality control of goods and services? (2/9)
a.	The employee undertaking the tasks
b.	Managers or work supervisors, specialist group or division within the firm or organisation, external groups – customers, external evaluation experts, etc.
40.	What proportion of the employees at this firm currently works in teams, where the members jointly decide how work is done? (2/9)
48.	What proportion of the non-managerial employees at this firm can currently choose when they begin or finish their daily work? (2/9)

The sub-questions in the indicator can be interpreted in multiple ways. One interpretation is that the perspective in the index mostly focuses on centralisation versus decentralisation. Several of the questions have an approach of hierarchical and vertical aspects. The question about organisational levels in the firm can be one of them. Two other questions that also can be included in this perspective include the one about the planning of the daily tasks and the one about the performance of quality control.

The question of proportion of employees that participate in self steering teams can also be seen as a question of decentralised responsibility, but it can also indicate a horizontal integration of work from different part of the organisation, and therefore it can also indicate the complexity of the organisation as well as a more process-oriented work organisation. Then again, the first question about the number of organisational levels can also say something about the complexity of the organisation. There is a greater need for several organisations levels if the organisation is more complex. The number of levels also indicates if the organisation is small or large; the larger the organisation is, the greater the need of several organisational levels. Researchers concerning teams are divided when it comes to the importance of teams in terms of economic performance, but they seem to agree that use of teams is increasing and that they are important when it comes to promoting structural learning in the organisation.

Possibilities such as the one implied in the question about flexibility in hours worked per day is often implemented with arguments that it affords the employees possibilities to organise family life or participate in personal leisure activities. It also ends up beneficial to the employers since the individuals can "fine tune" work load with family life.

Finally, the indicator of decentralisation gives information about decentralisation and some information about horizontal integration and the complexity of the organisations and its environment.

Concluding remarks on the indicators

As mentioned above, the indicators used are tentative and explorative. To summarise, the indicator of *individual learning* include formal and informal learning as well as continuous learning at work. The indicator *structural learning* provides information if the firm is building structural capital through systematic work with quality and innovations, and includes strategies about customer satisfaction. The indicator of *decentralisation* gives information about decentralisation and some information about horizontal integration, as well as it indicates the complexity of the organisations and its environment. Finally, *numerical flexibility* mainly gives information about changes of the workforce with short notice, and some information about work flexibility within the firm in terms of task rotation. It might also indicate the use of external workforce for knowledge transformation. Finally but already mentioned, there will be more profound analyses of patterns of practices and analyses of the idea about the firm's competence portfolio and links to the firm's environment in forthcoming papers.

During the process of this paper the insight has grown stronger that indicators might but do not have to gain from being constructed differently according to the cause. They might be constructed in one way if they are suppose to be explorative and in another way if they are to characterise for example certain industries or if they aim to be used to study different organisation and practices impact on people and firms, controlling for industries etc. Sometimes the intention is to combine these different analyses.

Correlations between the indicators

It is of interest to look into the correlation between these indicators to analyse if there are measurable relationships between them. First the correlation between the four indicators are presented, and secondly the correlation between all sub-questions within each indicator.

I have used the most common measuring of the degree of correlation, the Pearson correlation coefficient. It is widely used in the sciences as a measure of the strength of linear dependence between two variables. [62] The aim is to test a null hypothesis. A value of 1 implies a perfect relationship, with all data points lying on a line for which *Y* increases as *X* increases. A value of −1 implies that all data points lie on a line for which *Y* decreases as *X* increases. A value of 0 implies that there is no linear correlation between the variables. The interpretation of a correlation coefficient depends on the context and purposes. Cohen (1988), has observed that all such criteria are in some ways arbitrary and should not be observed too strictly. In social science a correlation close to 0.5 or -0.5 might be <u>very</u> high since other complicating factors contribute.

Correlation between the four composite indicators

The correlations between the four indicators are presented in Table 8. The table shall be interpreted as follows: Each indicator is presented in the head of a column, which shall be compared with the result of the other indicators presented on each row in the column. For example, the first column shows the correlation between Decentralisation and the four indicators. The first calculation shows at perfect correlation between Decentralisation and Decentralisation (1) this is of course obvious, since it is a correlation with itself. For each correlation the level of significance is presented. The lower the significance level, the stronger the evidence required, since this value is the probability of that the null hypothesis is true. For many applications, a level of 5 percent is chosen, and 1 percent is even better: that means that there is only one chance in a thousand this could have happened by coincidence. The highly significantly correlated indicators are marked with in blue print and light pink background, the negative in red.

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[62] The correlation coefficient is defined as the covariance of the two variables divided by the product of their standard deviations.

Table 8
Correlation analysis between the four composite indicators[63]

	DEC		NUM		STRUC		IND
DEC	1						
NUM	-0,06	**	1				
STRUC	0,24	****	0,17	***	1		
IND	0,21	****	0,11	**	0,31	***	1

Correlation Analysis Generated by SAS
*** High significance, the correlation is significant at the 0,01 level, i.e. it is under 1 percent chance that the result is a coincidence
** Rather high significance, the correlation is significant at the 0,05 level, under 5 percent is a coincidence
* Low significance, the correlation is significant at the 0,10 level, under 10 percent is a coincidence

Table 8 shows that between three of the indicators there are positive correlations: decentralisation, and structural and individual learning. Structural and individual learning are assumed to support each other. Individual learning can easier be developed to structural capital if there also is systematic work with quality and innovations in teams. Tacit knowledge that is assumed to be captured in the indicator of individual learning in work is of great importance in building structural capital. Both individual and structural learning are assumed to be even better supported if work is decentralised. Here, the positive correlation between the three indicators can be assumed to indicate that if the firm combines the different features it can achieve even higher value as a multiple effect, for example measured as productivity.

There is one negative correlation between numerical flexibility and decentralisation, but the correlation coefficient is low, as well as the level of significance that is almost 9 percent, which is the chance that it could have happened by coincidence. The interpretation implies that when numerical flexibility decreases, decentralisation increases, and vice versa. A decentralised work organisation characterised with individual and structural learning can be assumed to meet different kinds of demands and fluctuations. Since the work itself is organised in a more flexible way, the need for numerical flexibility in terms of extra work force on fixed contracts and from private

[63] Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations.

employment agencies might decrease. On the other hand numerical flexibility is positively correlated with all other indicators.

The correlations are not so high between the indicators that they can be interpreted as providing the same information. If the coefficients are too high, it is an indication that the indicators provide the same information.

Between sub-question in each indicator

Below are the correlations between all sub-question within each of the four indicators presented in tables 9 to 12. Each of the tables shall be interpreted the same way as the correlation above, which means that each sub-question is presented in the head of a column and shall be compared with the result of the other indicators presented on the rows of the column. The Pearson correlation coefficient is used to measure the strength of linear dependence between two variables to estimate a null hypothesis. For each correlation the level of significance is presented.

The interpretation of the result of estimations of these sub-questions can be even more difficult. For example a positive correlation between two sub-questions can mean that they partly provide the same information; therefore it can be a good thing if the questions do not correlate too highly, or it can be a good thing that they do not correlate at all. If so, they can be assumed to provide unique information. A negative correlation can mean that they are replaceable to each other, but it might also mean that they are partly excluding each other or that they do not belong to the same family of indicators. In any case, interpretations are assumed to be improved if they can be put into context, and step by step in different studies indicators will be put into context. The interpretation therefore is on a high aggregated level.

In the correlation analyses of the four indicators above, all questions were given a specific weight according to assumptions described. Even though most of the questions did have the same weight and were seen equally important, these weights are not at all included in the correlation between the sub-questions. Still the amount of optional answers in every question has been standardised so the construction of the question will not affect the importance of one question compared with another question.

Table 9 shows that some of the sub-questions have a positive correlation with other sub-questions whitin the indicator. I will comment on those that are highest positively correlated with a very high level of signicicance, and they are marked with blue print and a light pink background. The question that is included in more than one indicator is marked with a grey color.

Table 9
Correlation analysis between sub-questions in Individual learning

	96		102		100		94		99
96. is comp. dev. part of daily work	1								
102. prop. employees on-the-job training	**0,24**	***	1						
100. prop. employees non-paid time-off for training	0,10	**	0,07	*	1				
94. yearly evaluation of employee performance ?	0,14	***	0,09	**	0,07	**	1		
99. prop. employees paid time-off for training	**0,16**	***	**0,19**	***	0,13	***	0,12	***	1

Correlation Analysis Generated by SAS
*** High significance, the correlation is significant at the 0,01 level, i.e. it is under 1 percent chance that the result is a coincidence
** Rather high significance, the correlation is significant at the 0,05 level, under 5 percent is a coincidence
* Low significance, the correlation is significant at the 0,10 level, under 10 percent is a coincidence

The two questions that have the highest correlation are both about competence development in work. One is about if there is development in the daily work, question 96 and the other one is about the proportion of employees having on-the job-training, question 102. They can be assumed to partly contribute with the same information, but not totally since the estimation of the correlation is only about a quarter of the possible value (24 percent). The two questions about learning at work complement each other. Further, they seem to be correlated to a higher proportion of employees that can take part in training with paid time-off. The correlation is rather low, even though highly significant. These results are more or less expected.

The other two sub-questions are also positively correlated and the value of the correlation is low. These two later aspects can intuitively be seen as supporting the other questions, for example: assume that the employee participates in a training course that is basic and needed in the job, the training take place on paid time, and step two in the course is not needed at the current work. If the manager is possitive the employee can can take part in the next step but not on paid working time, therefore a correlation between paid and non paid training. If the non paid training is planned in advance the employee also have support of Swedish legislation[64] to take part in the training even if it will take place during working hours. But the employee can not expect to have paid time off from work for this training. This question is positively correlated with all other questions, with high significance, but in several cases with a rether low coefficient.

The second indicator that is analysed is structural learning, table 10. The main result from the estimation of correlation indicates that one sub-question is positively correlated with all other sub-questions in the indicator. It also indicates that one of the sub-questions is not significantly related more than one of the other questions. The question included in more than one indicator is marked with a grey color.

Table 10
Correlation analysis between sub-questions in Structural learning

	104		44		53		57		59		61		94
104. frequency of meetings between managers, workers?	1												
44. prop. employees participates in improvements groups?	0,17	***	1										
53. monitor quality of processes or service	0,07	**	0,08	**	1								
57. employees up-date data-bases of good work practices	**0,14**	***	**0,23**	***	**0,19**	***	1						
59. monitor external ideas or technological developments?	-0,02		0,04		0,03		**0,09**	**	1				
61. monitor customer satisfaction	0,03		0,09	**	**0,32**	***	**0,19**	***	0,06	*	1		
94. yearly evaluation of employee performance	0,03		**0,16**	***	**0,13**	***	**0,19**	***	0,07	**	**0,27**	***	1

Correlation Analysis Generated by SAS
*** High significance, the correlation is significant at the 0,01 level, i.e. it is under 1 percent chance that the result is a coincidence
** Rather high significance, the correlation is significant at the 0,05 level, under 5 percent is a coincidence
* Low significance, the correlation is significant at the 0,10 level, under 10 percent is a coincidence

[64] Lag om studieledighet 9.3.1979/273.

The question that is positively correlated to all other questions in the indicator is about if the employees up-date databases of good working practices, 57, it is correlated with high significance, with all but one question, 59, where the significance is a little lower. Up-dating databases can be seen as a core task in building structural capital. The later question is about monitoring external ideas or technological development and is it not correlated with any of the other sub-questions. The highest correlation is between the two questions concerning monitoring quality and monitoring customer satisfaction. Intuitively it can be assumed that they to some extent provide the same kind of information, but not totally. The interpretation of the correlation is that up to a third of all value they provide the same kind of information, but mostly they still complement each other.

There is also a rather high correlation between monitoring customer satisfaction and evaluation of the employee's performance. It can be assumed that firms that follow customer satisfaction to a greater extent include most of the employees in these tasks, and therefore it is logical that the firm also organises evaluations of the employees' performance, possibly concerning performance related to customer satisfaction, and even quality matters. The result that these kinds of evaluations are not related to a higher frequency of meetings between managers and workers. This would be interesting to investigate further.

Some other results are also of interest to further investigate, even the result that there is no linear relationship.

The third indicator analysed is decentralisation. Even for this indicator, the main result from the estimation indicates that one sub-question is positively correlated with all other questions in the indicator, see table 11.

Table 11
Correlation analysis between sub-questions in Decentralisation

	26		32		34		40		48
26. Numbers of organisational levels?	1								
32. who decides planning and execution of the daily work tasks: employees, managers?	-0,12	***	1						
34. who is responsible for quality control of goods, services: employee, manager/other?	0,01		**0,22**	***	1				
40. prop. employees works in teams, and jointly decide how work is done?	-0,06	*	**0,16**	***	0,12	***	1		
48. prop. non-managerial employees can choose when they begin or finish daily work?	-0,07	**	**0,26**	***	0,06	*	**0,21**	***	1

Correlation Analysis Generated by SAS
*** High significance, the correlation is significant at the 0,01 level, i.e. it is under 1 percent chance that the result is a coincidence
** Rather high significance, the correlation is significant at the 0,05 level, under 5 percent is a coincidence
* Low significance, the correlation is significant at the 0,10 level, under 10 percent is a coincidence

It seems to that the question about if the employees do their own planning and decide about the execution of their daily work tasks it is correlated to the possibility of having flexibility in when to start and end the daily work. Decentralised planning also seems to be positively correlated to other aspects of decentralised responsibilities, here quality control is measured. It also seems to be correlated with team work where the work is jointly decides how to be done. The correlations are highly significant.

There is a negative correlation between decentralisation and a larger numbers of organisational levels in the firm. This means that if there are several organisational levels the work is less decentralised, and vice versa, if there are fewer organisational levels the work is to a greater extent decentralised. Several organisational levels indicate a larger firm but also a more complex production. It might be assumed that there is a greater need to have an overview of work if the organisation is large and with many levels and more complex. The need to centralise the planning and have an overview is greater. This might explain the negative correlation. But to be able to really make stable conclusions, work practices in small respectively large firms need to be further investigated. I leave deeper analyses of different models to forthcoming papers.

Finally, the fourth indicator analysed is numerical flexibility. The indicator contains different features but it aims to provide information about flexibility in terms of possibilities to changes in the workforce with short notice, in terms of numbers of employees or hours worked, see table 12. The result shows that some of these features are positively correlated on a high significant level while others are not.

Table 12
Correlation analysis between sub-questions in Numerical flexibility

	51		12		11		14
51. are employees trained to rotate tasks?	1						
12. prop. employees with part-time?	-0,02		1				
11. prop. employees has temporary contract?	0,07	**	0,10	**	1		
14. prop. from private employment agency?	-0,01		0,05	#	**0,25**	***	1

Correlation Analysis Generated by SAS
*** High significance, the correlation is significant at the 0,01 level, i.e. it is under 1 percent chance that the result is a coincidence
** Rather high significance, the correlation is significant at the 0,05 level, under 5 percent is a coincidence
* Low significance, the correlation is significant at the 0,10 level, under 10 percent is a coincidence

Table 12 shows that the most direct ways to change the numbers of work force, measured in question 11 and 14, are the highest correlated with a high significant level in the indicator. The indicator also includes information about if the workforce is organised so that it is flexible within the firm in terms of task rotation. This practice is not correlated with the other aspects in the indicator. The third aspect in the indicator is part-time work, the estimation shows that it is not particularly correlated with the other features. In forthcoming papers there will be possibilities to elaborate further on different flexibility aspects.

Concluding remarks on the correlation

The four composite indicators are made to include as much different information as possible about work organisation and competence development. The object in this first explorative analysis of data is to study the relationship between the four composite indicators. The different correlations concerning the sub-questions in each indicator have given some insights about how much they provide the same kind of information. Since the correlation estimates are not too high this is not the case. The analyses also indicate how to go further into deeper analyses of relationships and patterns of practices in the firm, possibly using factor analyses. There can be some interesting patterns between the included sub-questions. In forthcoming analyses, measurements depending on underlying patterns might be one of the outcome, together with a discussion about how different features are related to the underlying theory, presented in the Meadow background reports. Different features that are included in the present four indicators will be further analysed as well as other features such as competence building outside the firms that seems to be of importance to highlight. The main conclusion from this analysis is that three of the indicators can be used in an index but the one measuring numerical flexibility is better used as a sole indicator by itself.

Incidence across industries in Sweden

Many researchers still have the picture of incidence and diffusion of decentralised work organisations and competence development across the Swedish business industries from earlier studies in the 1990s. The result of studies at that time showed that the incidences differed according to type of industry and their intensity of human capital and size. Will this overall picture of incidence change with this new data for 2010? A new perspective is included compared with the analyses during the 1990s, and that is if the firms are foreign controlled or Swedish controlled.

The described four composite indicators are used to describe the incidence and diffusion of work organisation and competence development across the Swedish business sector. They are; *Individual learning* that is assumed to indicate formal and informal learning, as well as continuous learning. *Structural learning* gives information about if the firm is building structural capital with the customer in focus, and if the firm work systematically with quality and innovations. The indicator of *decentralisation* provides information about decentralisation of responsibilities; some information about team-work that also can indicate the complexity of the organisations. Finally, *numerical flexibility* gives information about the possibility to change the number of employees with short notice and work flexibly within the firm, in terms of task rotation. It might also indicate use of an external workforce for knowledge transformation.

All presentation of data for 2010 is made with the help of descriptive statistics of the four composite indicators. The firms are weighed after their own industry's proportion of value added in the business sector. For each table the incidences and diffusion will also be compared with the earlier results in the two Swedish surveys from the 1990s. First of all, descriptive statistics provide some information of how the indicators are diffused. The first column in table 13 provides the number of firms per indicator. The second column is the mean value of the indicator in the business sector. As explained earlier each firm has a value of each index between 0 and 1. If a firm has the highest value in all indexes the value will be 4. Each indicator should be interpreted solely and not compared with the other indicators, since the construction of them does not allow this. The column presenting standard deviation (Std Dev) provides information of the general deviation from the mean value, i.e. plus (+) or minus (-) 0,23 for decentralisation

Table 13
Descriptive statistics of the four indicators: number of observations, mean, standard deviation, summa, minimum and maximum

	N	Mean	Std Dev	Sum	Minimum	Maximum
Decentralisation	795	0,43	0,23	346	0,01	0,92
Numeric_flexibility	802	0,30	0,13	243	0	0,83
Structural_learning	821	0,73	0,17	596	0,04	1
Individual_learning	767	0,64	0,33	493	0	0,96

Analysis Generated by SAS

The table 13 shows that in the Swedish Meadow survey there are firms that do not use numerical flexibility and individual learning practices, at least not the kind of practices that are measured in the survey. This is implied by the value 0 in the minimum column. There are firms with the highest value of structural learning as implied by the maximum value 1. Almost all firms answered all of the included questions, as can be seen in the number of observation for each composite indicator. The indicator with the highest number of observations also has the highest mean value, it is structural learning (0,73). It is these kinds of practices that have come in focus in endogenous theories about innovation and development. There will be more about these theories in forthcoming papers.

The incidence is higher in larger firms

Table 14 is to be interpreted as follows: For every index the mean value of all firms in the business sector is presented (last column) and the mean value of all firms that are small (15-49 employees) or medium (50-249) or large (250+) are also presented. In the bottom row the sum of the mean values of small, medium, large and the whole business sector is presented. The maximum value of the business sector can be 4.

Table 14
Incidences across firm sizes, mean values

	15-49	50-249	250+	Mean
Individual learning	0,56	0,61	0,73	0,63
Structural learning	0,63	0,69	0,77	0,70
Numerical flexibility	0,26	0,35	0,38	0,33
Decentralisation	0,45	0,40	0,40	0,42
Sum	**1,90**	**2,05**	**2,28**	**2,08**

The firms are weighted after their industry's proportion of value added in the business sector

Table 14 shows that there are differences between the sizes of the firms, but the mean values per indicator are not dramatically different. However, it is clear that larger firms have higher mean values in three out of four indexes. The argument for this can be that larger firms have more resources to invest in individual and structural learning, and also a greater need and possibility to organise the work with help of numerical flexibility, i.e. strategies such as task rotation and fixed contracts etc. If the question in the indicator of individual learning would not have been weighted upwards, it is possible that the difference would have been even greater between the sizes, since the up weighted feature is the one assumed least exact All the other questions in the index can be defined as ‘open’ investment in training, and large firms are to be handling such investments easier. Several of the questions in the index of structural learning can also be seen as indications of investments in structural capital.

The indicator of decentralisation shows the opposite picture. The smallest firms have a higher mean value than all the others. This is interesting. One argument can be that the smaller firms do not always have a deliberate decentralisation strategy since there are fewer levels of management, in very small firms only the executive director and then the rest of the staff. In these firms someone in the staff has to have the responsibility and make the day to day decisions. Another possibility is that the negative and significant correlations between the feature of organisational levels and the decentralisation of planning can explain the more modest frequency of the indicator among larger firms.

It is not easy to compare the current incidences of decentralised work organisation with data from the 1995 survey that are published, since the index differs a bit. In the 1995 survey the index is the top quartile of the work places that had the most decentralised work organisations in combination with daily learning. But it is also known that all of the top quartile had daily learning in the work so this will not differ according to the sizes. The top quartile is compared with all other work places. The incidence of the top quartile was about the same in all groups of work places that were smaller than the largest (500+). The frequency of top quartile work places in the largest group was about twice as high as in all other sizes. This means that all work places with small (50-99) and medium (100-199) and large (200-499) sizes but not the largest work places had about the same incidence. The data for 2010 in the largest group (250+) should be compared with the large ones and not the largest group of work places 1995. This is possible since we know from the collection report and the response rate (see footnote 33) that the number of the absolute largest firms is rather low in 2010. So when we are comparing the data this way the picture is about the same in 1995 as in 2010.

Differences across the business industries

Table 15. For every index the mean value of all firms in the business sector is presented (last column) and the mean value of all firms in different industry groups are also presented. In the bottom row the sum of the mean values of small, medium, large and the whole business sector is presented. The maximum value of the business sector can be 4.

Table 15
Incidences across industries, mean values

	Manufacturing		Capital intensive	Service		
	Labour intensive	Knowledge intensive		Trade & transport	Knowledge intensive	Mean
Individual learning	0,59	0,70	0,60	0,52	0,70	0,62
Structural learning	0,66	0,74	0,74	0,69	0,75	0,72
Numerical flexibility	0,31	0,34	0,32	0,32	0,29	0,32
Decentralisation	0,39	0,48	0,43	0,35	0,55	0,44
Sum	**1,95**	**2,26**	**2,09**	**1,88**	**2,29**	**2,09**

The firms are weighted after their industry's proportion of value added in the business sector, except for the finance industry here included in knowledge intensive service

Table 15 shows that the mean value is higher in the knowledge intensive industries, for three out of four indexes.[65] The mean value of numerical flexibility seems to be about the same in all type of industries. The incidences of decentralised work organisation and individual learning between the 1995 and 1997 and 2010 surveys, shows the same picture. See the comments to table 14, above, about the complexity to compare with the 1995 survey. The industries are aggregated from a two digital level to the five presented groups, see table 16 for type of industries on two digital levels.

[65] Generally there is a substitute between low-skilled labour and tangible capital and complementarities between high-skilled labour and tangible capital. If true it means that learning will be positively correlated between knowledge intensive and capital intensive. Se some recent papers: Autor D H, MIT and NBER, and Dorn D, CEMFI and IZA, 2010. *The Growth of Low Skill Service Jobs and the Polarization of the U.S. Labor Market*. Also published 2009. DP No. 4290. And Belhocine N. WP/10/86, IMF working paper. *The Embodiment of Intangible Investment Goods: a Q-Theory Approach*.

Table 16
Swedish standard Industrial classification, Nace 2007

Department	Two digital numbered industries, each industry is separated with semi comma	
Labour intensive manufacturing	10-15	Manufacture of food products; Beverages; Tobacco products; Textiles; Wearing apparel; Leather and related products
	18	Printing and reproduction of recorded media
	22	Manufacture of rubber and plastic products
	25	Manufacture of fabricated metal products, except machinery and equipment
	31-33	Manufacture of furniture; Other manufacturing; Repair, installation of machinery. equipment
Human capital intensive manufacturing	20-21	Manufacture of chemicals, chemical products; Basic pharmaceutical products
	26-30	Manufacture of computer, electronic and optical products; Electrical equipment; Machinery and equipment n.e.c.; Motor vehicles, trailers and semi-trailers; Other transport equipment
Capital intensive	16-17	Manufacture of wood, products of wood, cork, except furniture; manufacture of articles of straw and plaiting materials; Paper and paper products;
	19	Manufacture of coke and refined petroleum products
	23	Manufacture of other non-metallic mineral products; Basic metals
	35-39	Electricity, gas, steam and air conditioning supply
Trade, transport, post	46	Wholesale trade, except of motor vehicles and motorcycles
	49	Land transport and transport via pipelines
	53	Postal and courier activities
Human capital intensive service	58	Publishing activities
	61	Telecommunications
	62	Computer programming, consultancy and related activities
	63	Information service activities
	64-66	Financial service activities; Insurance, reinsurance and pension funding, except compulsory social security; Activities auxiliary to financial services and insurance activities
	71	Architectural and engineering activities; technical testing and analysis
	72	Scientific research and development

Source: SNI 2007 Swedish Standard Industrial Classification 2007. mis 2007.2.

Swedish work practices in foreign controlled firms

The definition of foreign controlled firm is that more than 50 percent of the voting value of the shares in the firm is held by one or more shareholder abroad.[66]

The foreign controlled firms in Sweden have increased since the middle of the 1990s, rapidly during the second half of the 1990s, and slower in recent years with a rate between 5-10 percent per year. Norwegian shareholders own the largest number of firms in Sweden, about 15 percent of all foreign controlled firms. Denmark is

[66] The definition is commonly decided in OECD and EU (Eurostat).

in second place and United Kingdom in third. The increase of foreign ownership is dominated by mergers and acquisitions. With regard to the number of employees, the US is largest, with almost a hundred thousand employees in the Swedish business sector. Today foreign controlled firms employ about 23 percent of all employees in the Swedish business sector. Foreign ownership is concentrated to the three metropolitan city regions.[67]

The foreign controlled firms are compared with national firms (last column), in table 14. The foreign ones are broken down by type of country: Asia, Europe, NAFTA, and the Nordic countries. The number of observations in Asia is low, and in the smallest size group it is zero. For every four indexes the mean value of small (15-49 employees) or medium (50-249) or large (250+) firms are presented in the Swedish business sector. The maximum value of each size group in the business sector can be 4.

Table 17
Incidences across ownership, mean values

	Asia	Europe	NAFTA	Nordic	Swedish
Individual learning	0,68	0,65	0,67	0,62	0,68
Structural learning	0,79	0,76	0,75	0,73	0,76
Numerical flexibility	0,56	0,44	0,40	0,46	0,43
Decentralisation	0,35	0,34	0,34	0,31	0,34
Sum	**2,38**	**2,19**	**2,16**	**2,12**	**2,21**

The firms are not weighted after their industry's proportion of value added in the business sector

Table 17 shows that in general the mean values are not dramatically different for any of the indicators according to foreign ownership of the business. The last column shows the mean value for the Swedish controlled firms. These values are almost identical compared with the first table, 14, which gives the mean value in every size group. It is not presented here but data divided into firm sizes shows that the mean values are fluctuating. For the smallest firms the mean values are higher than in the national firms, but on the other hand it is lower for the middle sized firms. The mean value for the group of large firms differs only marginally between the countries. So even with this fluctuation in mind the general picture still hold.

[67]The Swedish Agency for Growth Policy Analysis, 2010. Utländska företag 2009. Statistik 2010:04.

One partial explanation as to why foreign controlled firms in Swedish business sector do not differ more among themselves and from national firms is that these kinds of foreign direct investments in Sweden are dominated by mergers and acquisitions not greenfield investments[68], see also footnote 67. In countries like Sweden where the knowledge level in terms of technology and human capital is high, greenfield investments are uncommon. If you buy an existing business, it is much more probable that you also keep much of the culture and old ways to work, compared with if you set up something completely new.

Concluding remarks on incidences across industries

The study of incidence and diffusion of work organisation and competence development in the Swedish business sector shows that there are no dramatic differences across the business industries and ownership. Some differences according to sizes, the larger firms have higher incidences in three out of four indexes, but not decentralisation. The incidences seem to be higher in the human capital intensive industries, This is not surprising since it is assumed to be a relation between human capital intensiveness and at least the two kinds of learning indicators. An important reason of why the incidences of the four indicators do not differ dramatically according to foreign compared with Swedish ownership, is that foreign direct investments in Sweden are dominated by mergers and acquisitions etc and not so called greenfield investments. Other reasons are that the industrial relations seem to be strong and stable across the industries in Sweden and we know that the knowledge level is fairly high across industries.

What can predict the incidence?

Will the above presented differences of the incidences of the four composite indicators across industries stand in more complex models together with other features of the firm and the firm's work force? The aim is to answer the question with help of correlation analyses and regression models. Alongside the firm's size and

[68] Greenfield investments are investments in service business and in manufacturing or physical related structure in an area where no previous facilities exist. The name comes from building a facility literally on a "green" field, i.e. farmland or forest. They often occur when multinational corporations enter into developing countries to build new factories and/or stores. There was Greenfield investment in the Eastern European countries during the 1990s.

industry, and foreign ownership, some features of the firm's work force are included in the analyses, such as: age, education, and the proportion of men and women in the firm.

Correlation between the indicators and firm and work force features

First, estimations of the correlations between each indicator and the described features of the firm and its work force are done. The aim is to gain information about the relationship between each feature and indicator. The Pearson correlation coefficient to measure the strength of linear dependence is used. The results from the correlation analysis and the level of significance are presented in table 18. All positive correlations with high significance are marked in blue and all negative in red.

Table 18
Correlation matrix between the four indicators and other features

	IND		STRUC		NUM		DEC	
Foreign	-0,03		-0,10	**	**-0,13**	***	-0,01	
Small firms	**-0,23**	***	**-0,22**	***	**-0,35**	***	-0,00	
Medium sized firms	0,08	**	0,06	*	0,07	**	0,02	
Large firms	**0,18**	***	**0,19**	***	**0,32**	***	-0,02	
18 Industries, those with high sign.							**1 pos**	***
Young_ < 35	0,06		-0,02		0,07	**	0,06	*
Middle-aged > 35 < 50	-0,00		0,07	**	**-0,12**	***	**0,14**	***
Old_ > 50	-0,05		-0,03		0,03		-0,17	***
HighEdPerc university[1]	**0,15**	***	**0,22**	***	0,03		**0,26**	***
LowEdc compulsory[2]	**-0,16**	***	**-0,21**	***	-0,02		**-0,26**	***
MedEd Perc college[3]	-0,05		-0,09	**	-0,01		-0,11	***
Women[4]	0,07	**	0,10	**	**0,13**	***	**0,15**	***

Correlation Analysis Generated by SAS
1) University = ≥3 year or longer; 2) Compulsory school = 9 years schooling; 3) College = gymnasium and shorter university educations and courses, <3 year; 4) Woman, is a numerical variable
*** High significance, the correlation is significant at the 0,01 level, i.e. it is under 1 percent chance that the result is a coincidence
** Rather high significance, the correlation is significant at the 0,05 level, under 5 percent is a coincidence
* Low significance, the correlation is significant at the 0,10 level, under 10 percent is a coincidence

Table 18 indicates that almost all features are correlated with at least three out of four indicators, but there are one or two exceptions. The firm feature that provides most information is the size of the firm, according to the result of the correlation matrix. The firms are divided into three size groups of the same as in the presentation of incidences, see table 14. They are so called dummy variables, and each one is a feature that is correlated to the indicators. Large firms seem to be positively correlated and small firms negatively correlated with high incidence of three of the indicators, except for decentralisation. As mentioned previously, the sums of the incidences of the four indicators for each firm size are presented, and it differ between the largest and the smallest firms by almost 40 percent. The results in the correlation matrix strengthen the earlier findings that firm size matters.

Another firm feature is foreign ownership that is compared with Swedish ownership. The estimation indicates one significant but negative correlation with numerical flexibility. There is also an indication of a negative relationship between foreign ownership and structural learning, but the significance is not the highest. A negative correlation means that the incidence is lower if the ownership is foreign, compared to Swedish ownership, and vice versa, positive and higher if it is Swedish. Finally, the firm feature called type of industry is included. It simply measures the correlations between all 18 types of industries included in the calculation and each of the four indicators. Of all possible correlations between the included industries and the four indicators only 1 out of 72 are highly significant: it is the correlation between the industry group including Telecommunication (Nace 61) and Computing (Nace 62) and the indicator decentralisation. The weak relation between industries and the four indicators is the reason why the 18 groups of industries are not included one by one in the table.

Other included features are those of the work force. Two of these features provide the most information: they are sexes and education, according to the result in the correlation matrix. According to education that is a variable comprised by firms with different proportion of employees with high and low educations. Measured this way education is significantly correlated to three of the indicators, all but numerical flexibility. The firms with the highest proportion of university educated employees are positively correlated with three out of four indicators. Those with a higher proportion of employees with a low education are negatively correlated with three out of four indicators, and the third group is firms with a high proportion of college educated, and they are also negatively correlated with two of the indicators of structural learning and decentralisation. The result can be interpreted rather intuitively: firms with a high proportion of high educated are more likely higher incidences of all indicators but numerical flexibility.

The sexes of the employees are a feature that seems to be correlated to all of the indicators: the higher the percentage of women at the firm, the higher the incidence of the indicators, but with a different significance.

When it comes to the age of the work force there are fewer significant correlations, but it does seems to be related to three out of four of the indicators, all but individual learning. The firms are divided into three groups constituted by the age of the employees: The first group is characterised by a high proportion of employees under the age of 35. For these firms the result is not so clear, because the correlation value is low and the significance is rather low, but positive with numerical flexibility and decentralisation. The firms characterised by a high proportion of middle aged are negatively correlated with numerical flexibility, and positively correlated with structural learning and decentralisation. The firms that have the highest proportion of employees, 50+, are correlated negatively with decentralisation. The result of age can be interpreted rather intuitively: firms with a high proportion of middle-aged are more likely have decentralised work organisations than firms with higher proportions of younger and older employees. The middle-aged employeesare probably on top of their job career that includes decentralised responsibilities, such as planning and quality control etc.

The overall conclusion is that the matrix shows that there are correlations between almost all firm and work force features and the four indicators. Therefore a model that can take care of several of the non dependent variables simultaneously will be of interest to develop and use.

Regression model to predict incidences

The second calculation, based on a regression model, aims to study if the includes firm and work force features can predict the incidences of the four indicators. There is a relationship between this kind of calculation and correlations, with some significant differences. The linear regression model that is used includes all available information about the firm and the work force simultaneously. In other words, this model is measuring the relationship between one dependent variable, the indicator with several non dependent variables, the firm and the work force features, simultaneously. The non dependent variables are assumed to predict a higher or lower incidence of the dependent variable. All non dependent variables are included in an equation for each of the four composite indicators, one at the time. The non dependent variables are the same features as in the correlation: size and industry and ownership as well as features of the firm's work force: age; and education; and sexes.

For example, the feature of ownership is the same as in the correlation matrix; it is still divided into two variables but handled differently in the regression model compared to the correlation. Foreign owned firms are compared with Swedish owned firms, and the difference is the value that aims to predict the incidence. Here the value of the Swedish owned firm is included in the model's basic value, (I come back to this) and the values of foreign firms are presented in the table.

The firm size is still divided into three variables, as in the correlation. But in the regression model small and large firms are compared with medium sized firms, therefore the result of these two variables are presented in the table, and the third, the value of the medium sized firms, is included in the basic value.

With the same logic, firms with high proportion of young and old employees are compared with firms with higher proportions of middle-aged employees. Firms with higher proportion of employees with university and compulsory education respectively are compared to employees with college education. Finally the proportion of the sexes is included, This feature is constructed so that it measures and compares the result of every extra percent of women in the firm, and it is constructed as a numerical variable. Therefore it compares to each extra percent.

The value of each of the presented features in table 19 is compared with the sum of the basic value, intercepted, for each indicator. The basic value is calculated as the sum of the value of the following variables: the value predicted by the Swedish owned firms, plus the value it has as middle sized firm, and plus the value of middle aged employees, as well as the value of employees with college education, and finally the value of the lowest percentage of women in the work force is part of the basic value. So, the features that are presented in the table are compared with this basic value, either the presented features bring extra value or withdraw value from the basic estimation.

Once more, the features value respectively is interpreted as prediction of higher or lower incidence of each indicator. For example, in the model for predicting incidence of individual learning, the result indicates no significant value for the non dependent variable of the firm's ownership: foreign or Swedish. The feature of firm size withdraws value: if the firms are small (-12) this estimation is highly significant, and the indicator is given extra value if the firms are large (0.09) but with a little lower significance.

The results from all the four regression models, together with the level of significance are presented in table 19. All contributions of extra value with high or rather high significance are marked in blue, and all features that withdraw values are in red.

Table 19
Matrix of the result of four regression models: Individual learning; and Structural learning; and Decentralisation; and Numerical flexibility

	IND		STRC		DEC		NUM	
Foreign	0,04		-0,01		0,0003		-0,01	
Small firms	-0,12	***	-0,05	***	0,01		-0,06	***
Large firms	0,09	**	0,05	**	0,01		0,05	***
18 Industries, those with high sign.								
Young_ < 35	-0,08		-0,13	**	-0,09		0,05	
Old_ > 50	-0,18		-0,1		-0,24	**	-0,02	
HighEdc university[1]	0,05		0,15	***	0,19	***	0,01	
LowEd compulsory[2]	-0,08		-0,06		-0,12		0,02	
Women [3]	0,09		0,06	*	0,15	**	0,09	***

Generated by SAS System Model: Linear_Regression_Model
1) University = ≥3 year or longer; 2) Compulsory school = 9 years schooling; 3) Woman, is a numerical variable
*** High significance, the correlation is significant at the 0,01 level, i.e. it is under 1 percent chance that the result is a coincidence
** Rather high significance, the correlation is significant at the 0,05 level, under 5 percent is a coincidence
* Low significance, the correlation is significant at the 0,10 level, under 10 percent is a coincidence

Table 19 is a matrix of the result of four regression models, one for each indicator. The overall conclusion is that there are less significant estimations compared with the result presented in the correlations matrix. This means that the earlier result of the correlations explains more simple situations that are without the complexity of simultaneously impact of several features.

The results presented in table 19 of each regression i.e. each indicator is first commented on and secondly, the features, the non dependent variables, are commented across the regression models and indicators.

The conclusion of the result of each regression model provides information of if the included features, the non dependent variables, in the model suites the four models, the indicators, equally well. The conclusion is that they suit some indicators better than others. This is also clear in the test of how much of the variances in the dependent variable that can be explained by the non dependent variables. This test is commonly called R-Square (R^2). For the model of individual learning R^2 is rather low, 0.13. This means that the regression is nonlinear or the construction of the non dependent features is not suited to predict individual learning. Only one feature, the firm size, predicts incidences of individual learning. Structural learning is predicted by several features: size, education, age, sexes, and the result of the R^2 test is higher, 0.16. The regression model for decentralisation can be predicted by education, age, sexes, and the R^2 = 0,14. Numerical flexibility is predicted by size and sexes, and has the higher R^2 result of all of the models, 0,19.

It is also of interest to follow the importance of the different features, the non dependent variables, across the regression models. Only one features of the firm is still significant compared with the correlation matrix and predict a lower or higher incidence of the different indicators; it is firm size. Smaller firms predict significant lower incidence and larger firms predict higher incidence, compared with middle sized firms. This seems to be true for all indicators but decentralisation, according to this regression model. The other firm features like ownership and industry cannot predict the incidences of the indicators, according to the used regression model.

Several features of the work force predict the incidences of the indicators. A higher proportion of women predicts a higher incidence of three of the indicators but with different significance, and not for individual learning. Firms with a higher proportion of university educated employees predict the incidences for two of the indicators, structural learning and decentralisation. The age of the work force in the firms also predicts the incidence of structural learning and decentralisation. Firms with a higher proportion of young employees and firms with higher proportions of older employees are compared with firms with a higher proportion of middle aged employees. The result is negative or not significant. The conclusion is that the middle aged predicts a higher incidence of structural learning and decentralisation.

Concluding remarks on prediction of incidences

The correlation analyses and the regression model provide information of predictions of incidences of the four composite indicators. The correlation gives an over view and study the relationship between one feature at the time and the indicators. The regression model fine tunes the information and takes into consideration a more complex model of the firm and the work force.

The main result from all four regression models is that firm size and higher proportion of women in the firm predicts incidences of the indicators. Smaller firms predict a lower incidence of three of the indicators and larger firms predict higher incidences of the same indicators, compared to middle sized firms. This is true for all indicators but decentralisation. A higher degree of women in the firm increases the incidences of three of the indicators, but not individual learning. Firms with a higher proportion of university educated and firms with a higher proportion of middle aged employees predict a higher incidence of two of the indicators, structural learning and decentralisation.

A policy conclusion from these estimations is that in small firms almost all of these practices, except individual learning, are underrepresented, compared to medium sized and large firms. Some results in parallel analyses to this paper show significant results between individual learning and decentralisation and higher productivity. And also, earlier analyses in the 1990s showed these results, so policy actions can be defended. Both the firms and society can gain from actions that boost learning and decentralisation in smaller firms. Some background figures can contribute to the importance of small firms concerning their efficiency and productivity. The smaller firms constitute 99 percent of all firms in Sweden, and they comprise 44 percent of all export firms and their proportion of turnover is 49 percent, according to the Swedish

Business Register. Earlier policy programs promoting these practices in small and medium sized firms have been proven to be efficient[69].

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Work organisation, innovation and productivity

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Abstract

Does work flexibility matter for the productivity of innovative firms? This paper provides descriptive statistics of the relationship between innovation activity and work flexibility. There seems to be a strong positive correlation between different types of innovation and indicators for work organisation flexibility and also between multifactor productivity and work flexibility. Furthermore, a CDM-model is carried out to study the affect of work flexibility in the innovation process. The results show that more flexible firms invest more in innovation activities and this affects both innovation output and productivity.

1 Introduction

Innovation is one of the driving forces behind economic growth. Understanding the innovation process and the forces behind innovative activity are important when trying to explain economic progress. At the macro level indicators such as expenditure on R&D as share of GDP or total researchers as a share of total employment provide information on the innovation intensity in a country or region. But in order to provide a foundation in understanding a firm's decision to engage in innovation activities and factors influencing the innovation process, basic micro level data are needed. Today there are data available through the surveys conducted at Statistics Sweden which enable micro level analysis of firms' innovation activities and the construction of indicators on the behaviour of innovative firms'. In this paper the CDM model is used to study the innovation process. The model provides a framework to

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study the links between innovation input, innovation output and productivity.

One research area of the innovation process which has drawn limited empirical attention is the work organisational settings of the innovative firms. The meadow survey[71], recently conducted by Statistics Sweden, aims at studying the dynamics of work organisation and provides detailed information on the flexibility of firms' work organisation. Implementing the result from the Swedish meadow survey in the CDM framework provides an additional dimension to the understanding of the innovation process.

The business sector is constantly changing due to factors such as globalisation, competition and new technology. This puts firms under pressure to meet the demand of the market. Flexible firms which allow their staff to constantly improve their skills through individual learning and structural learning increases both the human capital of the firm and the employed, are more likely to meet this demand. In additional to the learning part there is also a component in which the employee can play a direct role in the development. Having influence over work hours, being able to make decisions without moving the decision making vertically are more likely, in our eyes, to provide a more flexible work organisation and improving the results. A seen later in this paper there is a positive and significant relationship between multifactor productivity and our variable measuring work organisational flexibility so without any theoretical motivation we are confident that this relationship is reasonable.

Hence, this paper should be seen as a novel and unprejudiced attempt in studying the affect of work organisational dynamics in the CDM framework. The organization of the paper is as follows: section two gives more information on the data followed by some results from descriptive statistics. Hence this part answers the question how are innovative companies structured? The fourth section presents the model used to study the innovation process and the fifth section presents the results. Finally, the concluding remarks are found in section six.

[71] For more information on the Meadow survey see http://www.meadow-project.eu/

2 Work flexibility and innovation

In this paper a CDM model is used. The model relates innovation input to innovation output and innovation output to productivity. The CDM model is a widely used approach to study the innovation process both in the academic literature and in the policy literature, see for e.g. Lööf and Heshmati (2002) and OECD (2009). One of the reasons behind the frequent use of the model is the problems associated the econometric modelling of the innovation process. Two of the main problems when estimating the relationship between R&D, innovation and productivity stems from the facts that firms which engage in R&D activities are a self-selected group and that prior productivity development affects investment in R&D (Johansson and Lööf, 2009, p 5). Hence, there is a selection problem and a simultaneous problem that needs to be solved. Crépon, Duguet and Mairesse (1998), henceforth CDM, solved these problems by using an instrumental variable approach and suggested a multi-step model in order to study the relationship. The specification of the model and the steps of the model have been modelled differently since the original paper but later studies conducted on Swedish data have used the Communication Innovation Study, henceforth CIS, combined with register data in implementing the model. CIS is a survey conducted every other year and is mandatory for EU member countries to conduct. The aim of the survey is to capture innovation activities in the member countries and is based on the Oslo manual developed by the OECD. In Sweden this survey has been conducted six times. The Oslo manual defines innovation into four categories: product innovation, process innovation, marketing innovation and organisational innovation. The definitions of these four categories are the following (OECD 2009):

> Product innovation: the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses.
>
> Process innovation: the implementation of a new or significantly improved production or delivery method.
>
> Marketing innovation: the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.

> Organisational innovation: the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations.

In the earlier rounds of the survey the definition of innovation was narrower and included only product and process innovation. Later rounds have included a wider definition, including marketing and organisational innovation. With the implementation of the Meadow survey, measuring the dynamics of organisations and work, yet deeper understanding of the factors and indicators influencing firms' innovation processes can be attained. In this paper no theoretical approach is used to study the influence of workplace organisation on innovative firms' performance. Instead a novel approach is used where data from the Meadow survey, register data and CIS data are used in order incorporate the organisational dimension into the CDM model.

2.1 Work organisation

The meadow survey provides information on the dynamics of organisations and work. Overall results and information on the meadow data regarding Sweden can be found the other papers in this yearbook see papers by Ahlstrand, Nylund and Hagén. From the survey data four composite indices are created to measure the dynamics of organisations and work: the extent to which the company supports individual learning and structural learning, how decentralised the organisation is and the degree of numeric flexibility. For more information on the motivation behind these four indices and how they are created, see Nylund 2010. These four indices can all together be seen as measuring the flexibility of the company. Hence the variable used in this study consists of the sum of these four indices.

3 Data and descriptive statistics

The sample used in this paper is based on firms included in the Swedish Meadow survey who also answered the Swedish CIS survey. The Meadow survey was conducted during 2010 whereas CIS was conducted during 2009 and collects information on innovation activity for a three year period from 2006 to 2008. The innovation indicators used are binary variables, whereas the work flexibility variable ranges from 0 to 4. The variables have been chosen accordingly with previous studies such as Hagén (2008). A list of the main variables used in this paper is presented in the appendix.

In the section above we stated the hypothesis that more flexible firms perform better. In order to test this we start by looking at the correlation between multifactor productivity (MFP) and work flexibility. Multifactor productivity is measured as the log of value added divided by the number of employed and work flexibility is the mean of the composite indices. The data for calculating MFP is taken from register data in contrast to work flexibility which is survey data.

Table 1
Correlation between MFP and work flexibility

Pearson Correlation Coefficients

	Work flexibility
MFP	0.14 0.0002 N= 740

As seen in table the correlation between MFP and work flexibility is positive and significant. However the magnitude of the correlation coefficient is somewhat small. To further investigate the relationship we ran an OLS regression with MFP as dependent and work flexibility as the independent variable in addition with control variables for industries.

Table 2
OLS regression on MFP and work flexibility

Dependent Variable: Multifactor productivity

Number of Observations Used 740

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	37.33181	4.14798	16.98	<.0001
Error	730	178.30038	0.24425		
Corrected Total	739	215.63220			

Root MSE	0.49421	R-Square	0.1731
Dependent Mean	6.55971	Adj R-Sq	0.1629

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	6.27927	0.13324	47.13	<.0001
Work flexibility		1	0.32164	0.11625	2.77	0.0058

In the OLS regression work flexibility is both positive and significant. The results from the tables above indicate that firms with higher flexibility have a higher MFP.

In order to get a first comprehension of the relationship between work flexibility and innovation, we calculated a correlation matrix between the innovation variables and the composite indices for work flexibility.

Table 3
Correlation matrix of composite work flexibility indices and innovation, Pearson correlation coefficients

	Product innovation	Process innovation	Organisation innovation	Marketing innovation	Share new to market	Share new to firm	Share barely new	Own developed
Individual learning	0.13250	0.12859	0.13101	0.09234	0.04913	0.06638	-0.07820	0.04379
	0.0002	0.0003	0.0002	0.0100	0.1710	0.0642	0.0292	0.2225
Structural learning	0.17664	0.16262	0.21912	0.11090	0.07921	0.06830	-0.09690	0.08123
	<.0001	<.0001	<.0001	0.0016	0.0246	0.0527	0.0059	0.0212
Numeric flexibility	0.10717	0.17191	0.09819	0.03183	-0.00763	0.03216	0.00011	-0.00408
	0.0026	<.0001	0.0059	0.3729	0.8308	0.3679	0.9976	0.9091
Decentralisation	0.09358	0.06267	0.08282	0.07540	0.02800	0.08195	-0.06926	0.02743
	0.0080	0.0759	0.0189	0.0326	0.4281	0.0202	0.0498	0.4377
Work flexibility	0.16869	0.18053	0.19208	0.09784	0.05302	0.09219	-0.09167	0.04509
	<.0001	<.0001	<.0001	0.0122	0.1750	0.0182	0.0189	0.2488

A majority of the coefficients are positive and significant. The individual indices show overall strong significant results with the four modes of innovation, marketing innovation and numeric flexibility being the exception. Studying the share new to the market/firm or barely new, we can conclude that these are much weaker results. Although the magnitude of the coefficients are small there seems to be a positive and significant relationship between the innovation modes and work flexibility.

4 The CDM model

Before the results of implementing work flexibility in the innovation process we briefly describe the underlying method. The CDM model consists of four equations. In the first step of the model we want to select firms which engage in innovation activities in order to explain which firms are innovators and which are not.

$$\boldsymbol{y_{0i}} = \begin{cases} \boldsymbol{1\ if\ y_{0i}^{*} = X_{0i}\beta_0 + \varepsilon_{0i}} > 0 \\ \boldsymbol{0\ if\ y_{0i}^{*} = X_{0i}\beta_0 + \varepsilon_{0i} \leq 0} \end{cases} \tag{1}$$

In the equation above $\boldsymbol{y_{0i}^{*}}$ is the innovation decision by firm i and $\boldsymbol{y_{0i}}$ the observed binary outcome taking the value 1 if the firm is an innovator and 0 if the firm is not, X_{0i} is a vector of variables explaining the decision to innovate. Thus, the equation above aims at explaining the propensity to innovate. The selective group of firms who engaged in innovation activities then decide upon how much to invest in innovation, i.e. innovation input. This is modelled in the equation below.

$$\boldsymbol{y_{1i} = y_{1i}^{*} = X_{1i}\beta_1 + \varepsilon_{1i}\ if\ y_{0i} = 1}\,, \tag{2}$$

where y_{1i} is the innovation input and X_{1i} the vector explaining the magnitude of innovation input. This is estimated using a Heckman selection model in which the estimated value of the expected value of the error term from (1) is used when running the regression in (2), using as an additional explanatory variable, the expected error. The expected error term used as an explanatory variable is usually referred to as the inverse Mills ratio, which corrects for the sample selection bias which occurs since the firms engaging in innovation activities is a self selected group.

The second step of the model uses an instrumental variable approach in which innovation input is related to innovation output which in turn is related to productivity. The second step starts by regressing the innovation output on the intensity to innovate attained from equation (2).

$$\boldsymbol{y_{2i} = \alpha_{21}y_{1i} + \alpha_{23}y_{3i} + X_{2i}\beta_2 + \varepsilon_{2i}\ if\ y_{0i} = 1}\,, \tag{3}$$

where y_{2i} is the innovation output, y_{3i} is productivity and X_{2i} the vector of explanatory variables explaining innovation output.

$$\boldsymbol{y_{3i} = \alpha_{32}y_{2i} + X_{3i}\beta_3 + \varepsilon_{3i}\ if\ y_{0i} = 1} \tag{4}$$

where y_{3i} is the innovation output and X_{2i} the matrix explaining innovation output. To solve the endogenity problem which occurs, equation (3) and (4) are estimated using two-stage least squares.

5 Results

This section is divided into two parts. The first part presents the results from using data from 2006-2008 and implementing the work flexibility variable in the CDM model. The second part uses innovation data from three different time periods. This enables us to test if we can explain more of the variance in innovation output and productivity by using innovation input from previous time periods.

5.1 Work flexibility in the CDM model

In all the equations estimated we control for industry. The result from estimating equation (1) is presented in the table below.

Table 4
Estimating equation (1), the selection equation

Parameter	Estimate	Standard Error	p-value
Work flexibility	0,23	0,43	0,59
Firm size	0,18	0,05	0,00
Human capital	0,11	0,08	0,15
Part of group	-0,23	0,14	0,09
Market local	0,00	0,15	0,99
Market national	0,35	0,18	0,05
Market EU	0,19	0,18	0,28
Market other	0,28	0,15	0,06

From the table above we see that the results of estimating the probability of the firm being innovative. The size of the firm seems to matter as well as the firm's market orientation. Local and other foreign markets are both positive and significant. Notably the work flexibility variable is not significant when estimating the probability of the firm being innovative.

Moving on to estimating the innovation input equation (2).

Table 5
Estimating equation (2), the innovation input equation

Parameter	Estimate	Standard Error	p-value
Work Flexibility	2,17	0,81	0,01
Firm size	0,06	0,08	0,47
Human capital	0,64	0,14	0,00
Cooperation index	0,07	0,04	0,10
Market local	0,41	0,28	0,14
Market national	0,82	0,35	0,02
Market EU	0,34	0,34	0,32
Market other	0,18	0,27	0,51

Equation (2) is estimated on the subsample of the firms who were selected as innovators in equation (1). We see that the human capital variable and one of the market orientation variables are significant and positive. Also the cooperation index is significant, but at the weaker 10 percent level. More interestingly the work flexibility variable is strongly significant and positive. Higher flexible firms increase the investment in innovation. The third equation, innovation output, provided the following results.

Table 6
Estimating equation (3), innovation output

Parameter	Estimate	Standard Error	p-value
Intercept	-5,45	2,39	0,02
Work flexibility	-0,49	0,95	0,60
Firm size	0,07	0,10	0,48
Human capital	-0,19	0,21	0,38
Marketing innovation	0,14	0,18	0,43
Organisation innovation	0,05	0,18	0,78
Cooperation index	-0,03	0,04	0,54
Improved distribution methods	0,18	0,20	0,37
Predicted innovation input	0,63	0,35	0,07

The results from estimating the innovation output shows very poor results. However, more important is that the predicted value of innovation input is positive and weakly significant. The work flexibility variable is not significant.

Finally the results from estimating equation (4), the productivity equation, is shown below.

Table 7
Estimating the productivity equation, equation (4)

Parameter	Estimate	Standard Error	p-value
Intercept	4,36	0,47	0,00
Work flexibility	0,00	0,39	1,00
Firm size	0,04	0,03	0,25
Capital per employee	0,38	0,18	0,03
Part of a group	-0,04	0,12	0,71
Salary per employee	0,00	0,00	0,15
Intermediate cost	-0,22	0,14	0,13
Predicted innovation output	0,35	0,09	0,00

The productivity equation shows that only two variables are significant: capital per employee and innovation output. Work flexibility is not significant.

From the above results we can conclude that the variable measuring work flexibility did not have a direct impact on either innovation output or productivity. On the other hand, the significant and positive result of the work flexibility variable on innovation input is a positive and interesting result. In the innovation input equation also human capital is included. A plausible explanation for this could be that innovative firms have a higher degree of employees with higher education and these firms need to be more flexible in order to pass on the human capital imbedded in the employees'.

5.2 CDM model – using three time periods

This part uses the CIS for three time periods: 2002-2004, 2004-2006 and 2006-2008. Each survey thus covers a three year period. This implies that the data covers the development from 2002 to 2008. Implementing this in the CDM model enables us to test if the innovation input from 2002-2004 has any affect on innovation output for the periods 2004-2006 or 2006-2008 etc. The results can differ from the ones presented in the section above since the whole sample included in the CIS is used. Industry is controlled for in all equations.

The table below presents results from estimating equation (1) for each time period.

Table 8
Estimating equation (1), the selection equation, for 2004, 2006 and 2008, only parameter estimates are shown.

Parameter	Year 2004	Year 2006	Year 2008
Firm size	0,081***	0,091***	0,119***
Salary per employee	0,000	0,010***	0,000
Part of a group	0,144**	-0,002	-0,040
Market local	-0,752***	-0,631***	-0,797***
Market national	0,220***	0,179***	0,030
Market EU	0,517***	0,657***	0,413***

The results above confirm the results from previous studies. Size of the firm and being active on the European market are positive and significant for all years increase the probability of the firm being innovative. Firms being active on the local market lower the probability whereas being active on the national market is positive but not significant for all years.

The table below presents the results from estimating equation (2) for each time period.

Table 9
Estimating equation (2), innovation input, for 2004, 2006 and 2008, only parameter estimates are shown.

Parameter	Year 2004	Year 2006	Year 2008
Firm size	0,243***	0,103	0,450***
Salary per employee	0,003***	0,006***	0,000
Part of a group	0,979***	0,237	0,946***
Cooperation index	0,370***	0,330***	0,452***
Market local	-0,421	0,228	0,629**
Market national	1,526***	1,128***	1,550***
Market EU	2,028***	1,612***	1,975***

The innovation input equation provides mixed results over the years. However, firms who are active on the national or on the European market invest relatively more than locally active firms. Being involved in several cooperation arrangements increases innovation input. Size of the firm is significant for two of the time periods but was nearly significant for the third time period as well, with a p-value close to 0,15.

Table 10
Estimating equation (3), innovation output, for 2004, 2006 and 2008, only parameter estimates are shown.

	Innovation input year					
	2004	2004	2004	2006	2006	2008
	Innovation output year					
	2004	2006	2008	2006	2008	2008
Parameter	(3.1)	(3.2)	(3.3)	(3.4)	(3.5)	(3.6)
Intercept	0,405	-24,154	5,608	0,214	-35,964**	-0,604
Firm size	-0,099***	-0,131	-0,140	-0,104***	0,056	-0,106***
Salary per employee	0,000	-0,008***	0,002	0,001	0,000	0,000**
Part of a group	-0,139	0,107	-0,509	-0,046	-0,746	-0,035
Improved production methods	-0,027	-0,342	0,374	-0,033	-0,035	0,153**
Improved distribution methods	0,289***	0,024	0,198	0,082	0,120	0,184**
Cooperation index	0,060	-0,223	0,146	0,024	0,163	-0,007
Predicted value of innovation input	-0,010	0,755***	0,120	-0,004	-0,382**	0,002

The table below show the results for equation (3). In columns 3.1-3.3 innovation input for the time period 2002-2004 is used. The predicted value of innovation input for this time period is then used as an independent variable in order to explain innovation output for 2002-2004, 2004-2006 and 2006-2008. In columns 3.4-3.5 the predicted value of innovation input for 2004-2006 is used as an independent variable in order to explain innovation output for 2004-2006 and 2006-2008. Finally column 3.6 uses the predicted value of innovation input for 2006-2008 to explain innovation output for 2006-2008.

It seems as predicting innovation output with the innovation input from the same time period provide poor results. However, using a one lag time period produced significant results. Innovation input for 2002-2004 came out positive and significant for explaining innovation output 2004-2006 in column 3.2. The negative parameter estimate for the predicted innovation input in column 3.5 could perhaps be explained by the fact that firms who invested heavily in 2004-2006 suffered relatively more because of the crisis compared with firms who invested less.

Table 11
Estimating equation (4), productivity, for 2004, 2006 and 2008, only parameter estimates are shown.

	Innovation input year					
	2004	2004	2004	2006	2006	2008
	Productivity year					
	2004	2006	2008	2006	2008	2008
Parameter	(4.1)	(4.2)	(4.3)	(4.4)	(4.5)	(4.6)
Intercept	9,637***	10,424***	12,733	8,937***	11,309***	8,874***
Firm size	0,083***	0,041	0,107	0,047***	-0,007	0,080***
Capital per employee	0,153*	0,185	0,182	0,343***	0,152	0,289***
Part of a group	0,113*	0,045	-0,010	0,194***	0,205	0,188***
Salary per employee	0,000*	0,002***	0,001***	0,000	0,001	-0,000***
Intermediate cost	-0,009***	-0,069***	-0,164*	-0,013**	-0,140*	-0,020***
Predicted value of innovation output	0,286***	0,182***	-0,050	0,314**	0,167***	0,347***

From table 10 we see that shorter time lags provide better results than longer time lags. Innovation output thus seems to affect productivity in the same time period. This means that the time lag between output and productivity is not that long.

It should be noted that these results should be interpreted carefully. The results might suffer from model misspecification and more model alternatives need to be tested before a final conclusion is possible.

6. Concluding remarks

Does work flexibility matter for the productivity of innovative firms? In this paper an indicator for work flexibility was constructed from the recently conducted Meadow survey. The variable was implemented in the equations of the CDM model. The results show that the work flexibility has an impact on how much firms invest in innovation and this thus affect innovation output and productivity. However, the result is weak and the data should be split on variables determining work flexibility such as domestic or international ownership, large versus small firms etc. Also the model specification needs to be tested.

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Appendix – variables in the CDM model

Variable	Description
Capital per employee	Log of fixed assets per employee
Cooperation index	Index of the number of cooperation arrangements on innovation activities
Firm size	Log of the number of employees
Human capital	Log of share of the total number of employees with an academic education
Improved distribution methods	Introduced onto the market a new or significantly improved logistic, delivery or distribution system
Improved production methods	Introduced onto the market a new or significantly improved method of production
Innovation input	Log of total expenditure for expenditure of intramural R&D, extramural R&D, acquisition of machinery and other external knowledge
Innovation output	Log of share of turnover in new or improved products that were new to the firm or the market
Intermediate cost	Share of intermediate cost in relation to total turnover
Market EU	Firm active on EU/NAFTA/CC market
Market local	Firm active on the local/regional market
Market National	Firm active on the national market
Market other	All other countries
Marketing innovation	Introduced onto the market a new or significantly improved marketing innovation
Organisation innovation	Introduced onto the market a new or significantly improved organisation innovation
Part of group	Firm part of a group
Productivity	Log of turnover per employee

Variable	**Description**
Salary per employee	Log of cost per employee
Work flexibility	Arithmetic average of the four composite indices: decentralisation, numeric flexibility, individual learning, structural learning

ICT, Organisation Flexibility and Productivity

Mater Thesis in Economics at Stockholm University
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With data from a Swedish survey an ICT composite indicator was created and related to measures of productivity and firm flexibility. The tests provided weak support for a positive relation between productivity and ICT while there are several aspects of firm flexibility positively related to ICT.

1 Introduction

Going back in time we may observe the impact of cars. When you use your car, as opposed to walking, certain things may go a lot faster and you may now, potentially, achieve more in less time and hence be more productive. On the other hand, when you are finally driving around to pick up your kids at soccer practice, shop for groceries, cut your hair and meet up with your friend there has already been a lot invested which you now benefit from. It has taken a great deal of effort in developing the car; further we have the roads, the rules and regulations and finally your (and others) ability to actually drive and manoeuvre the car.

When I put the above example in the context of *Information Communication Technology (ICT)* and try to understand the impact, I realise that I need not only investigate the number of computers but also how well integrated the work by computers is in the business, how well the staff understand the computers and how the managers organise the company and manage the information to benefit from the technology that is available. My notion is that ICT is good for growth and something that both firms and nations should pursue. For example this has been supported in the study by Claton, Franklin and Stam (2008).

However, it is not at all clear how to measure the relation or which variables within ICT that are the actual drivers toward higher growth. This problem is well covered in Brynjolfsson (1993) where he states that it is somewhat of a paradox that information technology has until then been reluctant to show up as a significant explanatory for productivity.

In this thesis my objective is to investigate how ICT relate to productivity and organisational structure of a firm. My first hypothesis is that there is a positive impact running through the chain of fast broadband to high ICT use to high productivity. This will be tested by following the development of a number of firms in Sweden over a 7 year period.

I am also looking to establish some facts about how organisational characteristics and ICT presence relate. My second hypothesis is that if high ICT presence can be thought of as high fluidity of information then the organisation will be positively affected in ways of flexibility; both structural and individual. With high ICT presence the firm organisation will be characterised by high measures flexibility. This will be tested by combining the ICT measure with different proxies for firm flexibility.

As the car needs roads to drive on - IT needs infrastructure, and someone at the (mouse) wheel.

2 Framework

Before getting involved in the data set and tests there is a brief section about the theoretical framework and structure of the thesis.

In the process of mapping the world there have been several studies investigating the relationship between economic growth and different explanatory variables. When referring to growth I let it be depicted by a change of a production function. The production function in turn tells me what level production is at. Further I let the production be the process of transforming input to output. Hence it follows that an increase in growth is derived from either an increase in the input or the productivity (Saari, 2006). Unless the price of input drops there will be a one to one relationship between the increases in production (benefit) and the increase in costs derived from the higher use of input, disregarding any possible economy of scale. Hence this will be an expensive way to pursue. Instead one might be better off with higher production by an increase in productivity. Even a small but consistent annual increase in productivity would be sought for as it will over time provide you with an exponential growth. This is why I focus my interest on something that may give a boost in productivity.

Obviously there are several factors that could reward you with a higher productivity and thus also economic growth. In this thesis I focus on the term *technology* in a wide sense and in connotation with *better* I would then mean the technique of achieving more with relatively less. The technology in general may then refer to your telephone, the structure in your garden shed and the way you motivate your kids when it is time to do homework.

As mentioned in the introduction I will measure the impact of *information and communication technology* (ICT). I then refer to both the use of information technology (IT), as in computers and internet, but also to the managerial part which involves means of organising the technology (communication).

More precisely I am interested in areas such as: *access and use of Internet, electronically managed business processes, integrated systems and e-trading*. Later on I will dig into the data and more specific survey questions that relates to each area.

The relation between ICT and productivity has previously been covered by a study from 2008 (Hagén, Glantz, & Nilsson)**.** They find that a higher-speed connection will lead to a higher ICT use the following year and that the reverse causality is not as significant. A high-speed connection is also related to a high productivity. Further they find that a high ICT use may lead to higher productivity in forthcoming years.

As part of my objective is the same as Hagén et al, the method will be similar and parts of the data used then will also be deployed now.

Hagén et al created an ICT composite indicator which was related to the productivity. The composite indicator consisted of four individual components: *Internet use (number of business activities), business system integration level (types of activities integrated with orders and purchase systems), online purchasing* and *online sales.* Points have been assigned for every variable within the individual indicator and in the end a representative ICT level is reached. The data used by Hagén et al was from the Swedish version of Eurostat's E-business survey covering the period of 2002 until 2006.

The study by Hagén et al is of special interest as I am using the same data set with the difference of three additional years of surveys

(2007, 2008 and 2009). To compare results I will have a similar setup in terms of ICT definition and test method. I will first create an ICT composite indicator and then test the causality of broadband connection, ICT and productivity.

Apart from that, and something that was not possible in 2008, I will be able to study my second hypothesis: organisational structure and ICT. The data is taken from an employer survey in Sweden which is part of the ambition of *Measuring the Dynamics of Organisations and Work,* from now on referred to the Meadow[72] Survey. The survey is further described in the next section.

As ICT provides possibilities in data processing enhancement it also influences how the company organisation is set up. My hypothesis is that a higher use of ICT will provide a free flow of information within the company, enabling a more flexible organisation. It will basically become an organisation where more individuals and functions have access to more information. The hypothesis of information flowing in the firm is also applicable when thinking about information moving within the firm over time. This will help the firm to be more flexible and adaptable which could be desirable in an ever changing world. Below follows description of my testable hypotheses.

My hypothesis of ICT as a proxy for information flow may enable flexibility in different dimensions. One dimension of flexibility might be evident in the organisation chart by its height and width. An increase in ICT could give more people access to more information quicker; enabling more decision makers and increase decentralization. Hence I want to test the relation between ICT and decentralisation.

ICT also opens up for more automated processes which could move the employee tasks from monotone routines towards more challenging work, including more analysis. This possibility could then lead a firm to use the information to learn more about both itself and its environment. Then I will try to capture aspects of individual and structural learning.

Further, the need for flexibility refers to both changing firm output and firm size. With easier access of information, higher ICT, the value of experience might decrease which could increase the use of

[72] More information about the survey and guidelines at www.meadow-project.eu

subcontractors or consultants. The number of subcontractors is one of the aspects I will try to capture in the numeric flexibility dimension. On the other hand, depending on the complexity of advance implemented systems the need for specialised staff which is educated and/or has experience for that specific system might increase.

The hypothesis described will be tested by using measures of decentralisation, numerical flexibility, structural learning and individual learning described and promoted by Anette Höglund (2010)[73].

Some of the hypotheses described above have already been verified in other studies. One study of special interest is Greenan and Walkowiak (2005). Using employees' data from 1997 they establish that the use of ICT is positively correlated with certain organisational characteristics. Attributes such as remote communication and participation in meetings, autonomy and management responsibility are favourable. It is also important how employees respect quality standards and at what frequency they communicate with their co-workers. They interpret this as that ICT and certain organisational attributes have a complementary relation. Consequently, when you increase the productivity on one of the two components then the other component will also get a certain share of that effect.

Bresnahan, Brynjolfsson and Hitt (2002) also found that the effect of IT on labour demand increased when used in combination with organisational investments and changes. They studied the three part combinatorial effect of information technology, complementary workplace reorganisation and new products on a firm level.

As indicated there are two different surveys used as basis for the data. On top of that I got the register data of all the observed companies. The next section will describe the data set more thoroughly.

3 Data

In this study I will work with tree different data sets: the ICT survey, the Meadow Survey and financial data.

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[73] Working paper, *Work Organisation and competence development in Swedish firms,* Statistics Sweden

3.1 The Use of IT in Swedish Enterprises – Survey

Since the year 2000 there has been a yearly survey conducted by Statistics Sweden trying to investigate the presence of IT in Swedish companies. The data is part of Sweden's official statistics (SOS classification) and from 2006 regulated by the European Union and Eurostat as part of a major task within the union[74]. The survey started as collaboration among the Nordic countries in 1999 and has developed ever since. From now on I will refer to this survey as the ICT survey. More details about the sample, coverage, reliability and survey development are available at Statistic Sweden[75]. Below is a short description of the sample of the 2009 survey.

Every year the survey was conducted during the second and third quarters and has been directed at Swedish Standard Industrial Classification (SNI 2007[76]) 10-82 which distinguishes companies in three different size groups related to the number of employees {[10-49], [50-249], [250 or more]} and also 10 different broad industry categories {*Manufacturing, Energy and waste management, Construction, Wholesale and retail trade; repair of motor vehicles and motorcycles, Transportation and storage, Accommodation and food service activities, Information and communication, Financial and insurance activities, Real estate activities, Other administrative and support service*}[77]. It does not include industries such as *Agriculture, Forestry, Mining, Education, Arts* and such industries where it is assumed to be less use and effect of IT.

The data may suffer from errors from different sources, lack of representativeness (as there is only a portion of the population), lack of answers and measurement error (due to misunderstanding and wide estimations). Companies with 250 employees or more were all included in the survey and considered rather represented. For companies with less than 250 employees there has been a stratified selection from every industry and if the stratum consists of 10 companies or less all of them have been selected. A positive co-selection between the years is used. From the 2009 survey the total

[74] EC nr 808/2004 from April 21 2004

[75] Statistics Sweden, SCB, 'IT användning I företag' www.scb.se/Pages/Product____15308.aspx

[76] European standard NACE Rev.2

[77] Detailed list at www.sni2007.scb.se/_pdf/080131snisorteradeng2007.pdf

sample consists of 4 315 companies but the sample size has varied over the years.

Measurement error that occurs due to misunderstanding is most evident amongst the quantitative questions but also amongst some of the qualitative questions. The response rate was 84 percent for the 2009 survey and rather consistent throughout the data set. This means that 16 percent of the companies did not respond at all. Further on there is a non-response for individual questions where a specific question about the use of IT for attempts to lower energy consumption got 20 percent non-response. This partial non-response will be considered when I use the data for building the ICT composite indicator.

The qualification for questions taken from this survey to create the ICT composite indicator is described in the Composite Indicator-method section.

3.2 The Meadow – Interview Survey

The Meadow Survey was conducted in late 2009 and early 2010 and relates to conditions of organisational structure in 2008 and 2007. The companies contacted are a selection of those that responded to the ICT survey earlier in 2009. The dimensions of flexibility sought after which are all part of my hypothesis are covered in the MEADOW Survey.

The respondents have been CEO, HR manager or at equivalent level. Each interview took about 15-30 minutes. Of the 1 374 companies (less over coverage) there were 874 (less interrupted) responses which equals a response rate of 64 percent.

The numerical flexibility measure aims to capture the firm's ability to change the input of work according to changes in demand. The two learning aspects together with the decentralisation measure are related to the firm's other form of flexibility. These other more organic forms of flexibility capture the firm's ability to adapt to a changing environment.

3.3 Extraction of these measures are described and promoted in the working paper by Anette Höglund (footnote 2) available at Statistics Sweden upon request. And the details and quality of the Meadow Survey will be published in the Productivity Yearbook 2010 by Statistics Sweden. For now there are working papers by Lana Omanovic (Quality of data in the Swedish Meadow Survey) available upon request at Statistics Sweden.Register data and Background Variables

In order to capture the effect of staff being more recipient of the use of ICT, a *Human Capital* measure has been created. It is a market oriented indicator where you basically let the staff cost represent the quality and ability of the employees. However, this indicator is not used in the ICT level composite indicator but instead used as a control variable in the forthcoming analysis.

Some firm specific characteristics have also been used as control variables, size (above or below 250 employees), use of networks [Intranet, extranet, LAN, and WLAN].

Together the human capital matrix and the firm characteristics matrix will form the **x** matrix and is used frequently in the subsequent calculations.

Last but not least in my data set description is the measure of productivity. There are many ways of measuring productivity and for my purpose there may be different options. One of the more straightforward ways is to have a ratio of the output of total sales and input of labour. In the previous study of Hagén et al it was a gross production multifactor productivity (GPMFP) that was used. However, this setup may be well suited when working on national accounts and especially differences over time, but is perhaps less appropriate on firm level. In this study I have settled with a value-added to employee ratio.

The next section describes the separate methods used for creating the ICT composite indicator, testing the ICT and productivity hypothesis, and testing of the ICT and organisation hypothesis.

4 Method of Analyis

4.1 Composite indicator Method

First, the purpose of a composite indicator is to describe a state of nature, or trend in an accessible way. The different indicators which are included represent different dimensions in the direction of the objective. In my case the objective is to put a measure on the presence of ICT to make further analysis and inference. As discussed earlier, ICT may obviously be measured in different ways and it is complex because it moves along different dimensions. When building my indicator to describe the use of ICT in a firm, there are several aspects to consider. These include the choice of variables (questions) and their weights used when combining them into one single indicator. To create an indicator that I can use for observing the development over time, I must find questions in the different surveys that are consistent in their formulation. As a guide on constructing the composite indicator, a publication of OECD (2008) has been consulted.

As mentioned, the questions that qualify as variables used will be based on availability throughout the years. This does slightly depart from the method deployed by Hagén et al (2008). They tried to find a definition of ICT that would change over time with the reasoning that high ICT in 2002 is not the same as high ICT in 2006. Consequently they did not observe the level but instead the rank of the resulting ICT indicator. However, my approach is somewhat more conservative as I will keep the ICT definition constant over time and observe the level provided by the created indicator. By doing so I am certain that whatever I measure, I am measuring the same thing. As also stated, by observing the levels, I use the information inherent in the actual difference between the years, which then becomes independent of how the other companies in the sample move. However, this might not capture the timing effect as well as when observing rank. The potential productivity increase as outcome of higher ICT might differ depending on the actions by the other companies in your industry.

The benefit of having the same definition over the years and observing the level is simplicity in setup and less room for uncertainty of what is being measured.

After a set of qualified consistent questions have been chosen they will all be scaled between 0 and 1. The weights, also referred to as loads in some literature, are based on their overlapping variations. The intuition of not saying the same thing twice corresponds to the method of factor analysis and principal components analysis. So after analysis of the separate years, I get a sense of a weight array for the variables.

It is in fact hard to know what exactly one measure, so I work under the assumption that high ICT is coveted so that I will see an increase in ICT over the years. This increase might fade away at the later years, an effect of having a constant definition of ICT. I will see this by observing the distribution over some companies that was present in all of the observed years.

Without any further statistical test I will then assume that I got a correct measure of ICT to set forth with. The reasoning behind the chosen variables and their weights are provided in the results section.

4.2 Relating ICT with Productivity and Broadband

To be able to answer the hypothesis that there is a positive impact running through broadband use to high ICT to high productivity, there will be a series of regressions performed. For me to also compare the results of Hagén et al (2008), the method will be similar to theirs.

The first question raised is what comes first: ICT use or the broadband connection? Hagén et al (2008) showed that even though both directions were significant, the one measuring the causality of high speed broadband to high use of ICT level was the strongest.

Through the three equations below I hope to answer that question.

Eq. 1

$$\log\left[\frac{P}{1-P}\right] = \alpha + \boldsymbol{\beta}\mathbf{x} + \varepsilon$$

Eq. 2

$$Y = \alpha + \boldsymbol{\beta_0}\mathbf{P} + \boldsymbol{\beta_1}\mathbf{x} + \varepsilon$$

Eq. 3

$$\log\left[\frac{P}{1-P}\right] = \alpha + \boldsymbol{\beta_0}\mathbf{Y} + \boldsymbol{\beta_1}\mathbf{x} + \varepsilon$$

Rho is a binary dummy for the use of broadband which in this study will equate any Internet connection faster than 2 Mbit/s and x is a matrix consisting of variables that might affect the use of broadband (background variables). Equation 1 is referred to as the selection equation where I find out which background variables to use in the forthcoming analysis.

The variable depicted by Y is the ICT level (the constructed composite indicator). All equations hold an error term, ε.

The Eq. 2 and Eq. 3 are used to decide which direction is the strongest. By using lagged values of the explanatory variable I will see how the effect varies and also avoid any problem with endogenous explanatory variables.

Equation 2 and 3 will be carried out by stepwise selection with a p-value for both step-in and step-out boundary of 0.15.

Then to find out if there is a positive impact running through broadband to high ICT to productivity, another two sets of regression are performed. Therefore I proceed with a two-stage regression using the following equations.

Eq. 4

$$Y = \boldsymbol{\rho} + \boldsymbol{\beta_1}\mathbf{x} + \varepsilon$$

Eq. 5

$$M = y + \boldsymbol{\beta_1}\mathbf{x} + \varepsilon$$

The estimate of ICT use that is explained by broadband use is produced in equation four and consequently put in equation five. So y in eq. 5 is the estimation of Y in eq. 4.

It is in the fifth equation where I also introduce the productivity variable, *M*. As earlier stated it is the value added labour productivity used.

So by observing how many periods significance holds all the way from broadband year 1 to ICT year 2 to productivity year 3 I will be able to state if the complete chain is evident and for which periods.

4.3 Relation between IT and Organisational Structure

This section will be the extended part where I also analyse how the organisational structure influences ICT and productivity through a cross sectional comparison. This will be done by studying correlations and by using Spearman's rank correlation coefficient. I may then see which organisational characteristics that have a positive correlation, and with a normally distribution approximation I may also calculate the significance. Basic OLS will also be used to support any conclusion. Both the correlation analysis and the OLS analysis will run with two different definitions of ICT. The two definitions of ICT are described in the results.

Eq. 6

$$Y_{1,2} = \alpha + \beta_1 x_1 + \beta_2 z_i + \varepsilon$$

In the OLS I put the two ICT definitions as response and a turnover variable together with one of the four organisational variables (*i* = 1-4) numerical flexibility, individual learning, structural learning and decentralisation as independent variable.

However, while studying these relations I will not plunge into any thoughts about the causality. The next section includes the results and will run through the creation of the composite indicator, the results of ICT and productivity and the results of ICT and organisation.

5 Results

5.1 Composite Indicator

As I will use the composite indicator that was created by Hagén et al (2008) as a starting point in my analysis, I will now take a closer look at its characteristics and update it with the new data before I again pick it apart and dissect it.

The composite indicator was based upon four sub indicators: *internet use, business system integration, online purchasing* and *online sales.* Hence the indicator:

ICT Level = Internet use + business level integration + online purchasing +
online sale

Internet use (USE) depicts the number of business activities that are supported by the Internet. For example, if the company had published product information and to what extent it uses the Internet when communicating with the government. The inclusion of *business level integration* (BSI) is motivated by Motohashi (2004) as well as by Clayton and Goodridge (2004) which proves the significance of well functioning business integration, both internally and externally, to achieve higher productivity. Online purchasing is a ratio of total turnover for each company and online sales is a ratio of total sales made over the Internet or automated systems.

Thus the ambition is to capture the level of the dimensions described above. The Hagén et al paper used data for the surveys published from 2003 up and until 2006. Over the years the survey has changed in its design, which led the authors to vary the variables within each sub-indicator. As stated before I will use a somewhat more conservative approach when constructing the index. In the next section I describe the data selection process.

In general my conservative approach leads me not make any assumptions to fill the information gap that appears when comparing data over the years. For me to be able to follow some companies over the years, I need to have variables that are consistent over the whole time span. First I look into the dimensions and variables available in the latest and most elaborate survey, from 2009. These are the preferred variables as they cover the dimensions well. Later I will make the elimination due to difference between the surveys.

The first indicator named *Internet Use* consists of 7 different binary questions regarding the presence of an information exchange within certain areas such as [purchase, receive invoice, receive order, product information, document for logistics, payment instructions].

Further I have the *Business Level Integration* which is an extension of the previous indicator and the companies' answers in more detail about what the electronic information exchange consists of. This exchange does not have to be an automatic one and concerns both external and internal integration. It adds up to not less than 13 binary variables. To analyse the indicator I have split them into one treating the questions of external integration with four questions of which two are toward the suppliers [(stock size, production plans/forecasts), state of delivery] and two are toward the customers [(stock size, plans/forecasts), state of delivery].

Business integration in the internal system consequently consists of 9 binary variables. First, four dealing with what happens when the company receives an order from a customer [updating stock level, accounting, production or service control, distribution control]. Similar variables concern actions when the company makes a purchase [updated stock levels, accounting]. One variable concerns whether the company distributes the sale and/or purchase information with other internal functions such as planning, marketing, controllers [ERP-system]. Finally, one variable concerns the existence of a CRM-system which could be used in two ways [collect and distribute client information, analyse the information for marketing purpose].

Online purchasing measures the level of purchases in relation to total turnover that was made through the Internet or other networks. A similar measure for the *online sale* out of total sales which was divided into intervals [<1percent, 1-4percent, 5-9percent, 10-24percent, 25-49percent, 50-74percent, >75percent].

These were the variables available in the 2009 survey, in total 22 of them. Moving back in time I will see which questions and intervals that could be used for consistent composite indicator.

As some questions have moved in and out of the survey over the years, may only look at those questions that are present in all of the surveys. Hence the variable set has been reduced to a total of 10 variables still representing the four dimensions, although in a somewhat rough way. The largest drawback is in the first dimension of *Internet use* which now only focuses on processes between the company and the government. The intervals for *online purchase* have also been cut down to only consist of the three options: 0, less than 1 percent or more than 1 percent. At any rate, the dimensions are regarded as relevant, because of their extent and because none of them hit the roof early in the period. The levels of the indicators were also all growing throughout the period.

	Variable number	ITANV2003	ITANV2004	ITANV2005	ITANV2006	ITANV2007	ITANV2008	ITANV2009	Description
INTERNET USE	1	7A	6A	9A	11A	7A	11A	9BA	Related to government - Search for information
	2	7B	6B	9B	11B	7B	11B	9BB	Related to government - Fetch forms
	3	7C	6C	9C	11C	7C	11C	9BC	Related to government - Submit completed forms
	4	7D	6D	9D	11D	7D	11D	9BD	Related to government - Completely electronically matter process
BSI	5	24A	23A	27A	24A	16A	26A- 27A-	**21A** 22A	Internal system for re-ordering replacement supplies
	6	24B	23B	27B	24B	16B, 20, 21	20-B 20-D	**16B** 16D	Invoicing and payment systems
	7	**24C**, 24D	23C	27C	24C	16C	26C 26D	**21C** 21D	Internal control of production, logistic or service operations
	8	24G	23E	27E	24E	16E	23A 23B	**18A** 18B	Suppliers' business systems (for suppliers outside your enterprise group)
ONLINE SELL	9	**17** 26A	**12** 26	**15B** 28B	**15B** 29B	**11B** 14B	30B	25B	In relation to total sales - share sold through network (Internet or EDI)
ONLINE PURCHASE	10	8A+27A < 1% = 0,5 > 1% = 1	7A+27A < 1% = 0,5 > 1% = 1	12B+29B < 1% = 0,5 > 1% = 1	14B+28B < 1% = 0,5 > 1% = 1	10B+13B < 1% = 0,5 > 1% = 1	32B < 1% = 0,5 > 1% = 1	28B < 1% = 0,5 > 1% = 1	In relation to turnover - share purchased through a network (Internet or EDI) [BINARY]

All of these individual questions which are used as variables are either a binary [0,1] or scaled between 0 and 1. The need of downsizing the number of variables rather drastically from the 22 available in the 2009 survey was caused due to changes in the survey design.

Thus far the variable selection has been on the basis of availability. The data is now ready to be further analysed, all being scored between 0 and 1. When it is time to piece them together I do not want to say the same thing twice. This lends me to factor analysis where I set out from the correlation matrix and with principal component analysis indentifying a number of factors (statistical dimension) by their eigenvalues (never less than 1). To get a clearer view of which variables are to be included in each dimension I rotate them using varimax rotation. The interpretation of the dimensions becomes less relevant and what I will focus on is to put a proper weight on all of the variables. Again this process was supported by guidelines of an OECD publication (Handbook on constructing composite indicators: Methodology and user guide, 2008)

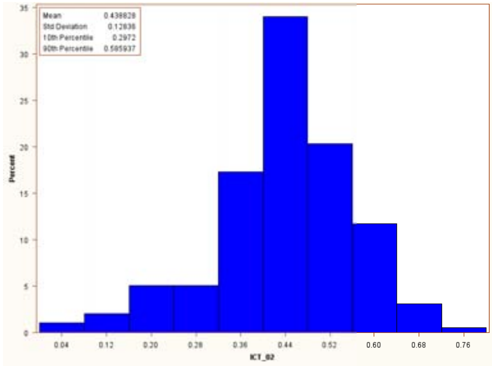
To get a fair view I will have to use the same weights on each of the variables in all of the separate survey. Hence the factor analysis provided me with one weight for each variable to be used on all of the surveys.

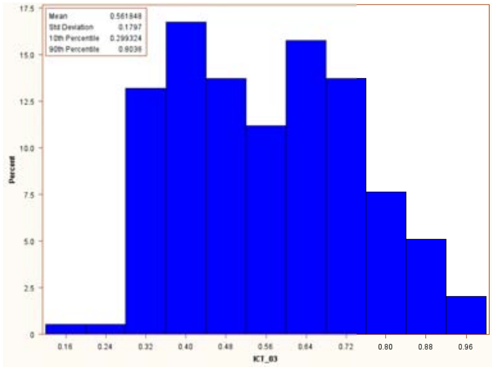
The way to construct one single indicator of the ten variables is done by a linear combination. The initial factor method was the principal component with the number of factors normally constrained by their eigenvalues not being less than one. The factors were then rotated by varimax rotation to maximise the load on each factor. The number of factors was never more than four and at least two, thus separating the 10 variables into two statistical dimensions with the *Internet Use* variables (four of them) from the rest. The factors were weighted according to their explained variance and below are the final weights which were chosen. Also displayed are the weights given if one would use equal weights within the conceptual dimensions and also the equal weight option as a reference.

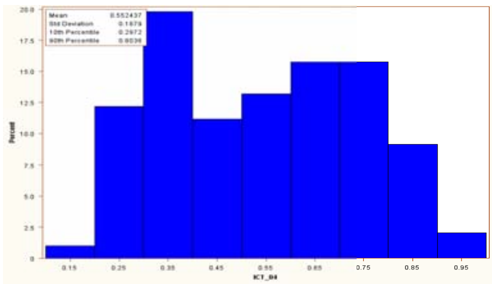
	Description	Equal Weights	Equal Weights within conteptual dimension	Rotated Principal Component Weights
INTERNET USE	Related to government - Search for information	0,1000	0,0625	**0,1470**
	Related to government - Fetch forms	0,1000	0,0625	**0,1502**
	Related to government - Submit completed forms	0,1000	0,0625	**0,1014**
	Related to government - Completely electronically matter process	0,1000	0,0625	**0,0765**
BSI	Internal system for re-ordering replacement supplies	0,1000	0,0625	**0,1174**
	Invoicing and payment systems	0,1000	0,0625	**0,1136**
	Internal control of production, logistic or service operations	0,1000	0,0625	**0,1213**
	Suppliers' business systems (for suppliers outside your enterprise group)	0,1000	0,0625	**0,0490**
ONLINE SELL	In relation to total sales - share sold through network (Internet or EDI)	0,1000	0,2500	**0,0708**
ONLINE PURCHASE	In relation to turnover - share purchased through a network (Internet or EDI)	0,1000	0,2500	**0,0527**
	SUM:	1,0000	1,0000	1,000

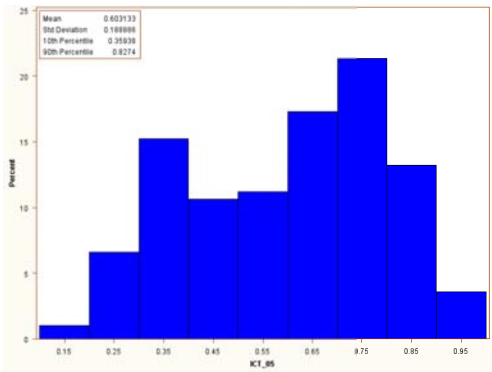
Throughout the years the variation of final weights was small enough to let me use an averaged value. This definition was used for the surveys of 2003 until 2009 which corresponds to the situation in the year prior to each survey. Hence the variables are named as ICT_02, …, ICT_8.

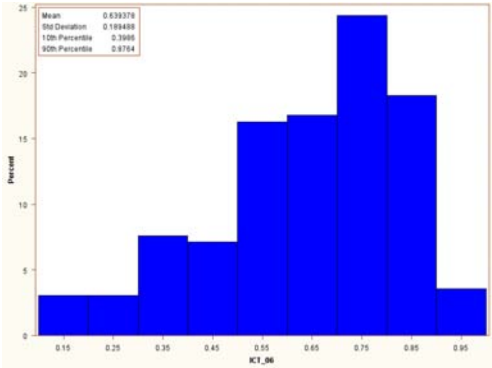
One thing that makes me content with the weights used is the distribution of the index values throughout the years. Although the weights were calculated on the basis of each year's full sample, I show the index distribution of the 197 companies that was present in all of the 7 years.

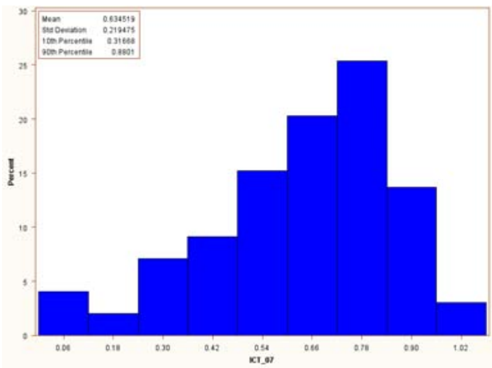

Mean 0.438828
Std Deviation 0.12836
10th Percentile 0.2972
90th Percentile 0.585937
Percent
0 5 10 15 20 25 30 35
0.04 0.12 0.20 0.28 0.36 0.44 0.52 0.60 0.68 0.76
ICT_02

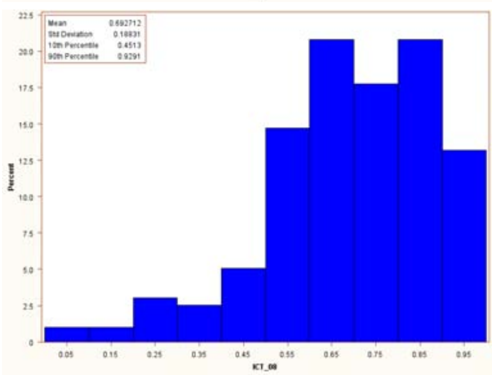

Mean 0.561848
Std Deviation 0.1797
10th Percentile 0.299324
90th Percentile 0.8036
Percent
0 2.5 5.0 7.5 10.0 12.5 15.0 17.5
0.16 0.24 0.32 0.40 0.48 0.56 0.64 0.72 0.80 0.88 0.96
ICT_03


Mean 0.552437
Std Deviation 0.1679
10th Percentile 0.2972
90th Percentile 0.8036
Percent
0 2.5 5.0 7.5 10.0 12.5 15.0 17.5 20.0
0.15 0.25 0.35 0.45 0.55 0.65 0.75 0.85 0.95
ICT_04


Mean 0.603133
Std Deviation 0.188886
10th Percentile 0.35938
90th Percentile 0.8274
Percent
0 5 10 15 20 25
0.15 0.25 0.35 0.45 0.55 0.65 0.75 0.85 0.95
ICT_05







Having the distribution leaning to the right is rewarding as the intuitive assumptions would be that the companies increase their ICT level over the years.

The definition just described is constructed within the limitations of survey questions throughout 2003 until 2009. However when relating ICT with other surveys (like the Meadow Survey for organisational attributes in hypothesis number two) from 2009 I may allow myself to use the full information scope. Hence a different variable set and weights might be used. This composite indicator will be aggregated with weights corresponding to equal weights within each dimension. This composite indicator is named ICT_08eqw.

	Variable number	ITANV2009	Description	Equal Weights	Equal Weights within conteptual dimensi
Automatic Exchange with external IT-systems	1	16A	Making orders from suppliers	0,0455	**0,0286**
	2	16B	Receive e-invoices	0,0455	**0,0286**
	3	16C	Receive orders from customers	0,0455	**0,0286**
	4	16D	Send invoices to customers	0,0455	**0,0286**
	5	16E	Send or receive product information	0,0455	**0,0286**
	6	16F	Send or receive information about logistics	0,0455	**0,0286**
	7	16G	Send payment instructions to financial institutions	0,0455	**0,0286**
Electronic information exchange with customer and supplier	8	18A	Share information about stock, production plan, demand forecasts - with suppliers	0,0455	**0,0500**
	9	18B	Delivery status - with suppliers	0,0455	**0,0500**
	10	19A	Share information about stock, productionplan, demand forecasts - with customers	0,0455	**0,0500**
	11	19B	Delivery status - with customers	0,0455	**0,0500**
Automatic information exchange within the firm	12	21A	Management of stock levels - when receiving orders	0,0455	**0,0222**
	13	21B	Accounting - when receiving orders	0,0455	**0,0222**
	14	21C	Control of production and service operations - when receiving orders	0,0455	**0,0222**
	15	21D	Distribution/Logistics Management - when receiving orders	0,0455	**0,0222**
	16	22A	Management of stock levels - when making a purchase	0,0455	**0,0222**
	17	22B	Accounting - when maing a purchase	0,0455	**0,0222**
	18	23	Does the company use a ERP system	0,0455	**0,0222**
	19	24A	Collect and store and share customer information - CRM system	0,0455	**0,0222**
	20	24B	Analysis of customer information for marketing purpose - CRM system	0,0455	**0,0222**
ONLINE SELL	21	25B	In relation to total sales - share sold through network (Internet or EDI)	0,0455	**0,2000**
ONLINE PURCHASE	22	28B	In relation to turnover - share purchased through a network (Internet or EDI) Points scored as middle of measured interval	0,0455	**0,2000**

This composition is more similar to the one defined in Hagén et al (2008).

5.2 Relating ICT with Broadband and Productivity – First hypothesis

Now that the ICT measure is complete I may move forward with the hypothesis testing. The first hypothesis concerned a positive impact running through a broadband connection through high ICT presence and on to high productivity. This is what Hagén et al (2008) stated in their report. The second hypothesis was about the relation between ICT and firm flexibility.

By showing the results from the selection equation I get a sense of which background variables could be sensible to use.

Summary Analysis of Maximum Likelihood Estimates								
Parameter	Response:	Speed_02	Speed_03	Speed_04	Speed_05	Speed_06	Speed_07	Speed_08
	P-value:	Pr > ChiSq	Pr > ChiSq	Pr > ChiSq	Pr > ChiSq	Pr > ChiSq	Pr > ChiSq	Pr > ChiSq
over250		<.0001	<.0001	<.0001	0.2380	0.4181	0.1858	0.0018
labour_quality		0.0389	0.0006	0.3495	0.7948	0.0958	0.5338	0.1649
Intranet		0.0036	<.0001	<.0001	<.0001	0.0077	0.0219	0.1668
Extranet		0.0619	0.0184	0.0005	0.4874	0.0404	0.0360	0.9778
LAN		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
WLAN		0.0011	0.0001	<.0001	<.0001	<.0001	0.3268	0.7616
IUSE		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

Equation 1 results above give me a good start before moving on. The background variables used were dummies for: firm over 250 employees, cost based labour quality, intranet use, extranet use, local area network use, wireless local area network use. The last one *IUSE* is the share of employees with Internet connection.

As seen the labour quality measure is only significant in the year 2003. Hence it will not be included in the forthcoming equations. It is also noteworthy that these background variables seem to become less important at the end of the observed period.

Before I go on and test the actual hypothesis, I also look into which direction that might be strongest: going from broadband to high ICT use, or the other way around. In the Hagén et al paper they stated in the tests, although with rather vague support, that it was more likely to go from broadband to ICT compared to the other way around.

The summary of the equation 2 results after the stepwise selection is shown below. As the requirement for a parameter to be included is a p-value of 0.15 there have not been any other not significant explanatory variables included in the regression. The full results are provided in the appendix.

Response: ICT		
Dependent variable is the speed from previous year	Estimate	Pr > F
Speed_02	0.02520	0.0074
Speed_03	0.06718	<.0001
Speed_04	0.04884	<.0001
Speed_05	0.06563	0.0062
Speed_06	0.10019	<.0001
Speed_07	0.12748	0.0062

Observe that the table above is a summary of 6 separate regressions. This is a homogenous result. So the high broadband use in year *t-1* is a significant explanation to high ICT use in year *t*. The next step is to test the other way around.

Below are the summary results after equation 3 which was also performed by stepwise selection, this time having the binary *Speed* as response. Again the other explanatory variables included were all significant at least on 0.15 p-value.

Response: Speed		
Summary Analysis of Maximum Likelihood Estimates		
Dependent variable is the ICT from previous year	Estimate	Pr > F
ICT_02	2.2170	<.0001
ICT_03	-	-
ICT_04	2.3800	<.0001
ICT_05	1.8708	0.0002
ICT_06	2.1298	<.0001
ICT_07	2.7963	0.0114

In the ICT_03 case the parameter value was not significant on anything below 0.15 p-value. Observe that the table above is a summary of 6 separate regressions. This result indicates that this direction was not as strong as 2003 ICT use was not a significant explanation for 2004 broadband use. However, the results are not very convincing and yet weaker than in the Hagén et al report. The full results are provided in the appendix.

After stating this I move on to test the first hypothesis, the chain of moving from broadband to ICT use and on to high productivity. As stated earlier this will be tested by observing a period over three years. For example, having the high productivity in year 2004 being explained by the part of ICT use 2003 that was in turn explained by broadband use in 2002.

Below are the results from equation 4, followed by equation 5 results if the Speed variable turned out to be significant in equation 4.

Summary Table of Equation 4 & 5 results				
Equation	Response	Dependent Variable	Estimate	Pr > F
Eq.4	ICT_03	Speed_02	-	-
Eq.5			-	-
Eq.4	ICT_04	Speed_03	0.03803	0.0581
Eq.5			-	-
Eq.4	ICT_05	Speed_04	0.06597	<.0001
Eq.5	Prod_06	predicted_ICT_05	249.23689	0.0801
Eq.4	ICT_06	Speed_05	0.09900	0.0004
Eq.5	Prod_07	predicted_ICT_06	568.61255	0.0042
Eq.4	ICT_07		-	-
Eq.5			-	-

In the cases where the results are blank then the dependent variable is not significant on anything less than 0.15. If the dependent variable was not significant in equation 4, the equation 5 was not performed. This shows some but weak support of the first hypothesis. It was possible two times of five where the whole chain was completed.

Having broadband in 2004 explains that the ICT in 2005 was significant. The predicted part of ICT in 2005 was also significant for explaining productivity in 2006. So this was one of the sub periods that supported the hypothesis. The next period was from 2005 through 2006 onto 2007. Again I end up having rather weak support for the hypothesis. The weakness of the results and especially the lack of significance for the last period could be because the ICT measurement was constant over time, which means that it successively becomes less relevant when the ICT develops. The full results are provided in the appendix and some more discussion about the result follows in the last section. But before that I also test for my second hypothesis, ICT presence and firm flexibility.

5.3 ICT and Firm Flexibility – Second Hypothesis

So by thinking about the ICT as a possibility of information to flow easily throughout the organisation both geographically and through time, I reasoned in the introduction that this should enable high flexibility in a firm. The data was taken from the Meadow Survey in 2009. The measures of flexibility were divided into different categories: decentralisation, numeric flexibility, structural flexibility and individual learning. The hypothesis was that there would be a positive correlation between each of these categories and ICT use, or at least some of them. The first test is performed with a Spearman correlation coefficient test, so that if the correlation was positive and significant, this would support my hypothesis. The categories of flexibility were tested against two different measures of ICT. As previously shown I used one measure based on 10 variables that worked well over the period from 2002 until 2008, the one I used in the first hypothesis testing. Then I created one measure that only worked with the variables provided in the 2009 survey, the ICT_08eqw composite indicator. The result with this indicator is of course much more interesting than those for the old indicator that did not change over time.

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations	DECENTRALISATION	NUMERIC_FLEX	STRUCTURAL_LEARNING	INDIVID_LEARNING
ICT_08eqw	0.07074	0.20978	0.22767	0.15068
	0.0462	<.0001	<.0001	<.0001
	795	802	821	767
ICT_08	0.04617	0.15702	0.17173	0.07586
	0.2159	<.0001	<.0001	0.0448
	720	734	748	700

The Spearman Correlation Coefficients of the two ICT measures in relation to the four different organisational measures from the Meadow Survey does provide me with some insight. First of all, I observe that the decentralisation had the lowest correlation and was only significant with just under 5 percent when using the ICT_08eqw measure. When the ICT_08 measure was used the coefficient was lower and not significant with p-value at 22 percent.

Numeric flexibility was clearly positively significant, independent of ICT measure. Structural learning was also positively significant for both ICT measures.

The last category of individual learning was positive and very significant for the ICT_08eqw measure but only at 4.48 percent when relating with the ICT_08 measure.

So even though this is a cross section analysis I would like to test for some background variables. I then included firm turnover and the summary of the equation 6 results is in the table below.

Summary of OLS				
Response:	ICT_08eqw		ICT_08	
Variable	Estimate	Pr > |t|	Estimate	Pr > |t|
DECENTRALISATION	0.05431	0.0864	0.03539	0.2899
NUMERIC_FLEX	0.19578	0.0002	0.20732	0.0002
STRUCTURAL_LEARNING	0.28600	<.0001	0.18739	<.0001
INDIVID_LEARNING	0.06088	0.0053	0.03669	0.1138

The table shows the results after the in total 8 linear regressions with the two ICT measures as response and one of the four organisational measures included at a time. Also the firm turnover was included in each regression. Full results are provided in the appendix.

Supporting the findings in the correlation test, all the indicators became significant with the rich and updated indicator ICT_08eqw. However, the decentralisation now has a p-value of 8.64 percent and it was not significant when using the ICT_08 measure. This means that the relationship between the more decentralised firms and the firms that use ICT more intensively is much weaker than with the other flexibility modes. Discussion and Conclusions

5.4 Broadband, ICT and Productivity

Having the results just presented I may conclude that, first of all, measuring ICT is not a straight road to go down on. But with the data available I have been able to capture how the companies have evolved in a forward direction within this definition of ICT. The variables included in the composite indicator were supported by theory and also used in a previous study. Even though I have kept the definition of what would be a high presence of ICT constant over my measuring period, it has still been a relevant measure as it has not yet hit the roof and it is still moving upward. Obviously, over a longer period of time the definition of high ICT use will change as new technology is developed together with new possibilities. But for this study a constant definition seemed both appropriate and feasible. By doing this I also diverted a bit from previous study that partly used the same data. With this setup I also got a bit weaker support for the hypothesis.

There was no clear support that ICT being followed by broadband should be any more likely compare to broadband being followed by ICT. Clearly it goes together with the reasoning that having a good broadband might make the firm realise what possibilities there are with more ICT. But the other way around make sense also as a firm that already has high ICT use might see that the effect of these systems will increase even more if the Internet connection was increased.

The first hypothesis was that there was an impact of broadband running through ICT and onto productivity in a series of years. With the first test just discussed, the weak support of the following tests came with little surprise. So the hypothesis was picked up from the earlier study but only partly supported in my result with only two out of five periods of significant relations. This could be due to the fact that the indicator used in my test was the same over time.

Obviously I am not measuring the exact same thing, especially as the ICT composite indicator was created in a different way. In a discussion of what ICT measures, it must first be understood that the definition of ICT is not carved in stone. And as with all composite indicators, there are many means of constructing the indicator. There are also no fixed rules about how to go forth with the process. This study has much leaned on the guidelines set up by OECD and it is certain that the indicator created is appropriate for the analysis. However, there is no great support for earlier findings within the field.

5.5 ICT and Organisation

The second hypothesis in this study was the positive relation between ICT and numerical flexibility, individual learning structural learning and decentralisation. With the Spearman correlation rank coefficient being positive and yet well significant for all but decentralisation, I see that there is much to learn here. Even when pairing one of the explanatory variables with firm turnover and then controlling for firm size in an OLS, the relations seem evident.

The flexibility measure of decentralisation was concluded as not being positively significant. It was only on the correlation test using the ICT_08eqw measure where decentralisation slipped in just under 5 percent of significance. In the OLS which controlled for firm turnover, both the ICT measures confirmed decentralisation was not significant.

Thus the hypothesis was that there would be a positive relation between ICT and decentralisation, but as a consequence to the result the reasoning continues. It might well be that ICT works in both ways on decentralisation. By thinking about ICT as the fluidity of information, the need of personnel being spread out geographically should be less and then decentralisation should decrease. While working in the other direction, there is the option of more decentralisation as more people may have access to more information and are able to make decentralised decisions. However, one would have to separate the data to find support for this notion.

That numerical flexibility is positively significant with high ICT goes well together with the notion that ICT might enable a numerical flexibility where functions might be scalable and flexible. It is easier for new staff to get involved in their job when there is more information available, so the barrier for hiring could be lower. The same reasoning works just as well in the other direction: it becomes easier to let employees go when less demand makes you cut down on production.

When looking at individual learning, the two measures of ICT somehow contradict each other. But in the OLS with ICT_08eqw you may see that the parameter coefficient is not that very large, but still significant. Meanwhile with the ICT_08 the coefficient is just slightly smaller and insignificant. In the correlation test, individual learning was significantly independent of ICT measure with a p-value of 4.48 percent at the most. Hence the hypothesis got some support and the ICT is used in combination with individual learning.

In contrast to individual learning where the relation was somewhat vague, the structural learning is positively significant. Again referring to ICT as a proxy for fluidity of information within the firm, it is possible that it becomes easier for a firm to develop when more information is available and a better basis for decisions is at hand.

The general conclusion is that ICT is at work together with high flexibility where the firm may stay well updated with its surroundings both in terms of size and knowledge.

5.6 End notes - How the results will be used

For now the results hold with notion of ICT as a measure of information flow within the firm and that this is something beneficial and desirable. The data might benefit from further analysis, be split into the different industries and so forth.

The results will be brought together with other studies of the Meadow Survey for further understanding of what goes on within the firm. It was discussed at the International Productivity Conference at Saltsjöbaden (Stockholm, Sweden) on 6-7 October 2010. The publication of the *Yearbook on Productivity 2010* by Statistics Sweden will contain many of these different studies and will be published in December 2010.

Both the ICT Survey as well as the Meadow Survey will continue and develop even further. This would make longer time series possible as well as enable other types of analysis. Hopefully this work will be a good starting point for such endeavours.

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7 Appendices

7.1 Equation 1 Results

Response: Speed_02		
Analysis of Maximum Likelihood Estimates		
Parameter	Estimate	Pr > ChiSq
Intercept	-1.6053	<.0001
over250_02	0.9747	<.0001
labour_q02	0.000746	0.0389
Intranet_02	0.3027	0.0036
Extranet_02	0.2260	0.0619
LAN_02	0.8374	<.0001
WLAN_02	0.3857	0.0011
IUSE_02	1.1924	<.0001
Number of Observations Read		3006
Number of Observations Used		2781
Response Profile		
Ordered Value	Speed_02	Total Frequency
1	0.00	1185
2	1.00	1596

Response: Speed_03		
Analysis of Maximum Likelihood Estimates		
Parameter	Estimate	Pr > ChiSq
Intercept	-1.8046	<.0001
over250_03	1.9305	<.0001
labour_q03	0.00360	0.0006
Intranet_03	0.6707	<.0001
Extranet_03	0.5657	0.0184
LAN_03	1.5020	<.0001
WLAN_03	0.9367	0.0001
IUSE_03	1.7771	<.0001
Number of Observations Read		2999
Number of Observations Used		2720
Response Profile		
Ordered Value	Speed_03	Total Frequency
1	0.00	489
2	1.00	2231

Response: Speed_04		
Analysis of Maximum Likelihood Estimates		
Parameter	Estimate	Pr > ChiSq
Intercept	-1.7613	<.0001
over250_04	0.8284	<.0001
labour_q04	0.000409	0.3495
Intranet_04	0.5805	<.0001
Extranet_04	0.4636	0.0005
LAN_04	1.0289	<.0001
WLAN_04	0.6068	<.0001
IUSE_04	1.5031	<.0001
Number of Observations Read		2944
Number of Observations Used		2651
Response Profile		
Ordered Value	Speed_04	Total Frequency
1	0.00	900
2	1.00	1751

Response: Speed_05		
Analysis of Maximum Likelihood Estimates		
Parameter	Estimate	Pr > ChiSq
Intercept	0.1242	0.3080
over250_05	0.4977	0.2380
labour_q05	-0.00003	0.7948
Intranet_05	0.9207	<.0001
Extranet_05	0.2300	0.4874
LAN_05	1.7863	<.0001
WLAN_05	1.0748	<.0001
IUSE_05	1.4185	<.0001
Number of Observations Read		2926
Number of Observations Used		2627
Response Profile		
Ordered Value	Speed_05	Total Frequency
1	0.00	217
2	1.00	2410

Response: Speed_06		
Analysis of Maximum Likelihood Estimates		
Parameter	Estimate	Pr > ChiSq
Intercept	0.1624	0.4420
over250_06	0.2800	0.4181
labour_q06	-0.00114	0.0958
Intranet_06	0.5092	0.0077
Extranet_06	0.5507	0.0404
LAN_06	1.4202	<.0001
WLAN_06	1.0982	<.0001
IUSE_06	2.0223	<.0001
Number of Observations Read		2686
Number of Observations Used		2427
Response Profile		
Ordered Value	Speed_06	Total Frequency
1	0.00	232
2	1.00	2195

Response: Speed_07		
Analysis of Maximum Likelihood Estimates		
Parameter	Estimate	Pr > ChiSq
Intercept	-0.1915	0.1701
over250_07	0.4176	0.1858
labour_q07	0.000182	0.5338
Intranet_07	0.4879	0.0219
Extranet_07	0.5402	0.0360
LAN_07	1.9238	<.0001
WLAN_07	0.2293	0.3268
IUSE_07	2.2069	<.0001
Number of Observations Read		3557
Number of Observations Used		3184
Response Profile		
Ordered Value	Speed_07	Total Frequency
1	0.00	255
2	1.00	2929

Response: Speed_08		
Analysis of Maximum Likelihood Estimates		
Parameter	Estimate	Pr > ChiSq
Intercept	-0.6711	0.0048
over250_08	1.1029	0.0018
labour_q08	0.00105	0.1649
Intranet_08	0.2782	0.1668
Extranet_08	0.00630	0.9778
LAN_08	2.1429	<.0001
WLAN_08	-0.0636	0.7616
IUSE_08	2.6551	<.0001
Number of Observations Read		3442
Number of Observations Used		3410
Response Profile		
Ordered Value	Speed_08	Total Frequency
1	0.00	302
2	1.00	3108

7.2 Equation 2 Results

Response: ICT_03		
Variable	Estimate	Pr > F
Intercept	0.29027	<.0001
Speed_02	0.02520	0.0074
over250_02	0.06746	<.0001
IUSE_02	0.02268	0.0747
WLAN_02	0.03733	0.0005
LAN_02	0.11414	<.0001
Extranet_02	0.01808	0.1087
Intranet_02	0.03965	0.0003
Number of Observations Read		1986
Number of Observations Used		1833
Number of Observations with Missing Values		153

Response: ICT_04		
Variable	Parameter	Pr > F
Intercept	0.23069	<.0001
over250_03	0.07191	<.0001
labour_q03	-0.00005539	0.0334
Intranet_03	0.04373	0.0004
Extranet_03	0.03272	0.0084
LAN_03	0.10564	<.0001
WLAN_03	0.03870	0.0016
Speed_03	0.06718	<.0001
Number of Observations Read		1876
Number of Observations Used		1706
Number of Observations with Missing Values		170

Response: ICT_05		
Variable	Parameter	Pr > F
Intercept	0.24816	<.0001
over250_04	0.07275	<.0001
labour_q04	-0.00009201	0.0355
Intranet_04	0.05440	<.0001
Extranet_04	0.05502	<.0001
LAN_04	0.14468	<.0001
WLAN_04	0.04141	0.0003
Speed_04	0.04884	<.0001
Number of Observations Read		1916
Number of Observations Used		1726
Number of Observations with Missing Values		190

Response: ICT_06		
Variable	Parameter	Pr > F
Intercept	0.22162	<.0001
over250_05	0.09803	<.0001
Intranet_05	0.04090	0.0024
Extranet_05	0.03296	0.0135
LAN_05	0.11503	<.0001
WLAN_05	0.05667	<.0001
IUSE_05	0.05207	0.0012
Speed_05	0.06563	0.0062
Number of Observations Read		1697
Number of Observations Used		1519
Number of Observations with Missing Values		178

Response: ICT_07		
Variable	Parameter	Pr > F
Intercept	0.17741	<.0001
over250_06	0.07697	<.0001
labour_q06	0.00008573	0.0576
Intranet_06	0.05802	<.0001
Extranet_06	0.05665	<.0001
LAN_06	0.12903	<.0001
WLAN_06	0.01963	0.0876
Speed_06	0.10019	<.0001
Number of Observations Read		1887
Number of Observations Used		1706
Number of Observations with Missing Values		181

Response: ICT_08		
Variable	Parameter	Pr > F
Intercept	0.33871	<.0001
over250_07	0.07000	<.0001
Intranet_07	0.08849	0.0002
Extranet_07	0.03306	0.0305
WLAN_07	0.06531	<.0001
Speed_07	0.12748	0.0062
Number of Observations Read		779
Number of Observations Used		766
Number of Observations with Missing Values		13

7.3 Equation 3 Results

Response: Speed_03		
Analysis of Maximum Likelihood Estimates		
Parameter	Estimate	Pr > ChiSq
Intercept	-1.0402	<.0001
over250_02	1.7745	<.0001
Intranet_02	0.4108	0.0208
LAN_02	1.1381	<.0001
WLAN_02	0.7635	0.0177
IUSE_02	1.9563	<.0001
ICT_02	2.2170	<.0001
Number of Observations Read		1986
Number of Observations Used		1833
Response Profile		
Ordered Value	Speed_03	Total Frequency
1	0.00	288
2	1.00	1545

Response: Speed_04		
Analysis of Maximum Likelihood Estimates		
Parameter	Estimate	Pr > ChiSq
Intercept	-1.6205	<.0001
over250_03	0.7905	<.0001
labour_q03	0.00271	0.0038
Intranet_03	0.5377	<.0001
Extranet_03	0.5148	0.0024
LAN_03	0.7437	<.0001
WLAN_03	0.3911	0.0157
IUSE_03	1.0035	<.0001
Number of Observations Read		1876
Number of Observations Used		1706
Response Profile		
Ordered Value	Speed_04	Total Frequency
1	0.00	509
2	1.00	1197

Response: Speed_05		
Analysis of Maximum Likelihood Estimates		
Parameter	Estimate	Pr > ChiSq
Intercept	-0.2028	0.2453
Intranet_04	1.2572	<.0001
LAN_04	2.0984	<.0001
ICT_04	2.3800	<.0001
Number of Observations Read		1916
Number of Observations Used		1726
Response Profile		
Ordered Value	Speed_05	Total Frequency
1	0.00	129
2	1.00	1597

Response: Speed_06		
Analysis of Maximum Likelihood Estimates		
Parameter	Estimate	Pr > ChiSq
Intercept	0.3848	0.0495
Intranet_05	0.6403	0.0107
LAN_05	0.9664	<.0001
IUSE_05	1.1456	0.0014
ICT_05	1.8708	0.0002
Number of Observations Read		1697
Number of Observations Used		1519
Response Profile		
Ordered Value	Speed_06	Total Frequency
1	0.00	110
2	1.00	1409

Response: Speed_07		
Analysis of Maximum Likelihood Estimates		
Parameter	Estimate	Pr > ChiSq
Intercept	0.0590	0.7610
Intranet_06	0.6815	0.0048
LAN_06	1.4265	<.0001
IUSE_06	0.8422	0.0135
ICT_06	2.1298	<.0001
Number of Observations Read		1887
Number of Observations Used		1706
Response Profile		
Ordered Value	Speed_07	Total Frequency
1	0.00	115
2	1.00	1591

Response: Speed_08		
Analysis of Maximum Likelihood Estimates		
Parameter	Estimate	Pr > ChiSq
Intercept	0.4067	0.4403
Intranet_07	1.3609	0.0335
LAN_07	1.2962	0.0900
ICT_07	2.7963	0.0114
Number of Observations Read		779
Number of Observations Used		766
Response Profile		
Ordered Value	Speed_08	Total Frequency
1	0.00	17
2	1.00	749

7.4 Equation 4 & 5 Results

EQUATION 4 Response: ICT_03		
Variable	Estimate	Pr > F
Intercept	0.27903	<.0001
over250_03	0.05026	<.0001
Intranet_03	0.06579	<.0001
Extranet_03	0.03494	0.0032
LAN_03	0.13175	<.0001
WLAN_03	0.04250	0.0004
Number of Observations Read		1331
Number of Observations Used		1214

EQUATION 4 Response: ICT_04		
Variable	Estimate	Pr > F
Intercept	0.17576	<.0001
Speed_03	0.03803	0.0581
over250_04	0.04773	0.0018
Intranet_04	0.05868	0.0001
Extranet_04	0.03338	0.0236
LAN_04	0.14539	<.0001
WLAN_04	0.06020	<.0001
IUSE_04	0.03141	0.0968
Number of Observations Read		1293
Number of Observations Used		1179

EQUATION 4 Response: ICT_05		
Variable	Estimate	Pr > F
Intercept	0.23410	<.0001
Speed_04	0.06597	<.0001
over250_05	0.08149	<.0001
Intranet_05	0.02397	0.1326
Extranet_05	0.03963	0.0084
LAN_05	0.14321	<.0001
WLAN_05	0.04258	0.0019
Number of Observations Read		1180
Number of Observations Used		1048

EQUATION 5 Response: PROD_06		
Variable	Estimate	Pr > F
Intercept	-343.65250	<.0001
predicted_ICT_05	249.23689	0.0801
labour_q06	2.65900	<.0001
IUSE_06	135.28632	0.0019
Number of Observations Read		1180
Number of Observations Used		1045

EQUATION 4 Response: ICT_06		
Variable	Estimate	Pr > F
Intercept	0.19678	<.0001
Speed_05	0.09900	0.0004
over250_06	0.08782	<.0001
Intranet_06	0.03605	0.0228
Extranet_06	0.07422	<.0001
LAN_06	0.08405	0.0004
WLAN_06	0.06147	<.0001
IUSE_06	0.04848	0.0080
Number of Observations Read		1277
Number of Observations Used		1147

EQUATION 5 Response: PROD_07		
Variable	Estimate	Pr > F
Intercept	-173.49522	0.0546
labour_q07	1.43862	<.0001
Extranet_07	68.01519	0.1071
IUSE_07	189.21436	0.0008
predicted_ICT_06	568.61255	0.0042
Number of Observations Read		1277
Number of Observations Used		1147

EQUATION 4 Response: ICT_07		
Variable	Estimate	Pr > F
Intercept	0.25430	0.0005
Extranet_07	0.07484	0.0017
LAN_07	0.27558	0.0004
WLAN_07	0.07281	0.0032
Number of Observations Read		367
Number of Observations Used		365

7.5 ICT and Organisation Results

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations	DECENTRALISATION	NUMERIC_FLEX	STRUCTURAL_LEARNING	INDIVID_LEARNING
ICT_08eqw	0.07074	0.20978	0.22767	0.15068
	0.0462	<.0001	<.0001	<.0001
	795	802	821	767

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations	DECENTRALISATION	NUMERIC_FLEX	STRUCTURAL_LEARNING	INDIVID_LEARNING	ICT_08eqw
ICT_08	0.04617	0.15702	0.17173	0.07586	0.70428
	0.2159	<.0001	<.0001	0.0448	<.0001
	720	734	748	700	797

Response: ICT_08eqw		
Parameter Estimates		
Variable	Estimate	Pr > |t|
Intercept	0.20548	<.0001
TurnOverMSEK	0.02239	<.0001
DECENTRALISATION	0.05431	0.0864

Response: ICT_08eqw		
Parameter Estimates		
Variable	Estimate	Pr > |t|
Intercept	0.17666	<.0001
TurnOverMSEK	0.01711	<.0001
NUMERIC_FLEX	0.19578	0.0002

Response: ICT_08eqw		
Parameter Estimates		
Variable	Estimate	Pr > |t|
Intercept	0.02676	0.3660
TurnOverMSEK	0.01997	<.0001
STRUCTURAL_LEARNING	0.28600	<.0001

Response: ICT_08eqw		
Parameter Estimates		
Variable	Estimate	Pr > |t|
Intercept	0.19322	<.0001
TurnOverMSEK	0.01876	<.0001
INDIVID_LEARNING	0.06088	0.0053

Response: ICT_08		
Parameter Estimates		
Variable	Estimate	Pr > |t|
Intercept	0.57023	<.0001
TurnOverMSEK	0.01682	<.0001
DECENTRALISATION	0.03539	0.2899

Response: ICT_08		
Parameter Estimates		
Variable	Estimate	Pr > |t|
Intercept	0.53099	<.0001
TurnOverMSEK	0.01144	<.0001
NUMERIC_FLEX	0.20732	0.0002

Response: ICT_08		
Parameter Estimates		
Variable	Estimate	Pr > |t|
Intercept	0.45506	<.0001
TurnOverMSEK	0.01278	<.0001
STRUCTURAL_LEARNING	0.18739	<.0001

Response: ICT_08		
Parameter Estimates		
Variable	Estimate	Pr > |t|
Intercept	0.56655	<.0001
TurnOverMSEK	0.01306	<.0001
INDIVID_LEARNING	0.03669	0.1138

Work organisation and differences between sexes

1 Introduction

This paper is part of a larger work called Flex 3. Flex 3 is using a new international survey on work organisation called Meadow, *Measuring the Dynamics of Organisations and Work*. The Project Manager of this survey and analysis in Sweden is Hans-Olof Hagén at Statistics Sweden.

In this part of the Flex 3 focus is on analysis of work organisation and differences between sexes. Our starting point when deciding about how to measure differences between sexes was the Swedish equality policy, which says that "The overall objective of Sweden's gender equality policy is to ensure that women and men have the same power to shape society and their own lives. Gender equality also contributes to economic growth by encouraging the development of people's skills and creativity. Women and men shall have the same rights and opportunities to be active citizens and to shape the conditions for decision-making. Women and men shall have the same opportunities and conditions with regard to education and paid work that provide them with the means to achieve lifelong economic independence. There shall be an equal distribution of unpaid care and household work. Women and men shall take the same responsibility for household work and have the same opportunities to give and receive care on equal terms."[78]

For many years the Swedish Government has facilitated for both men and women to combine a paid job and family life. Elderly care and child care are two important steps. As early as 1974 fathers were able to use parental insurance and stay at home with a sick child receiving sickness benefit[79]. Today parents are entitled to parental insurance for 480 days in total; where 60 days are reserved to each parent. Parents are able to split the 360 days remaining as they wish.

[78] http://www.sweden.gov.se/content/1/c6/13/36/75/910bd4ad.pdf , Ministry of Integration and Gender Equality, Gender equality

[79] http://www.forsakringskassan.se/irj/go/km/docs/fk_publishing/Dokument/Rapporter/socialforsakringsrapporter/forandringar_i_socialforsakringen_2005_01.pdf

As most of the parental insurance days were, and still are, used by women, the Swedish government took another step in the gender equality work and introduced an equality bonus. Parents who had children born after 30 June 2008 are able to receive the bonus if both parents take at least 2 months parental insurance each. The equality bonus can be maximum SEK 13 500 (approximately EUR 1 500) per year and child if parental leave is split exactly between the two parents.

In April 2010 about 81 percent of the male population age 20-64 were employed, whereas the same figure for females was nearly as high, 75 percent[80]. Among EU member states Sweden had the second highest female labour force participation in 2007[81]. But even though the share employed is almost the same, other things are not. "The degree of occupational segmentation tends to be higher the higher is the degree of women's presence in the labour market"[82]. The proportion of part-time women workers in total employment in Sweden is according to Eurostat data around 40 percent. The mean for the EU27 is 31 percent. The men's share is also above the EU27 average, 12 percent compared to 8 percent in EU27.

But not only do Swedish women work fewer hours, they also work in segregated occupations and sectors, and their gross hourly earnings were 18 percent less than for men in 2007[83]. The difference cannot only be explained by differences in educational level, as women in general have achieved a higher educational level, with one small exception. Men are still overrepresented among post graduates.[84] Women perform a higher share of unpaid work such as domestic and family work. That is one possible explanation for the unequal Swedish labour market. Another explanation is the glass ceiling where old attitudes and culture prevents women from reaching higher positions.

A factor of the growth in OECD for the past ten to fifteen years can be explained by the increasing number of women in the labour force.[85] "Women still have not attained equality with men and their

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[80] http://www.scb.se/Pages/ProductTables____23272.aspx, Labour Force Surveys, Statistics Sweden.

[81] EU Commission, 2009

[82] OECD, 2002, p. 65

[83] EU Commission, 2009

[84] Statistics Sweden, 2009

[85] OECD, 2008

productivity potential is not used at its best"[86]. In order to raise one country's or the whole world's productivity it is crucial to involve women more in the labour force. Sweden, as said before, has a high proportion of women participants in the labour force, but not always on the same conditions as men. From the firms' point of view they would presumably use the competence of both men and women in best way possible, in order to maximise profit.

Our measure of the differences between sexes in the Swedish labour market will be based on the Swedish Government's view of gender inequality in the labour market. Differences between sexes in the Swedish labour market will be divided into two indicators: career and parenthood.

The first indicator, career, will consider firms' differences between men and women when it comes to leading positions and income. Do men and women to the same extent have leading positions within the firm and have they equalled mean income?

The second indicator for differences between sexes, parenthood, is suppose to tell us whether parents have the same responsibility for their children in order to be able to have the same ambitions in work. We believe that two things dominate for parents when deciding about how to split the parental leave and VAB days (parents have the right to care for sick children at home while receiving financial compensation from the social security system): their own preferences and their work situation. By work situation we mean if you are unemployed, have a loose relationship to the labour market or are on temporary contract and the workplace's attitude for child caring. From our data we will have no possibilities to find out anything about individuals personal preferences. We therefore have to assume that the individual preferences are equally occurring over firms. What we can measure is the outcome or impact of the decisions. The questions to be answered by the parenthood indicator are: do men and women use the same number of days for parental leave and are they staying at home an equal number of days with their sick children?

Two problems appear: the segregated labour market and the high proportion of part time working women. Some of the problems are reduced as the public sector is excluded in this analysis due to restrictions in the Swedish Meadow Survey. The private sector is

[86] OECD, 2002

assumed to be more competitive and less family-friendly, even though the differences are large between firms.

There are other problems to take into consideration. Only one third of the employees in the private sector are women. Therefore some firms will be excluded as they lack data on for example one of the sexes use of parental leave. Nevertheless the hypothesis regarding income is equal income for equal work, and women and men shall have the same proportion of leading positions. In a gender equal society our believe is that women and men should be able to work the same number of hours both at work and at home. Therefore our view is that no differences in income would be accepted due to differences in work hours.

In this study we are not able to analyse the difference in power, roles and other gender equality aspects of the working life, only some impact measurements. This impact is due to the attitude in the society that influences decisions taken by the individuals and their families on the one hand and the attitude and decisions taken by managers and colleagues at their work places on the other hand.

The aim of this paper is to analyse whether firms with bigger differences between sexes are under- respectively overrepresented in firms with different kinds of work organisations. Can work organisation explain any of the sex differences between firms?

Common for most of the analysis done in Flex 3 is the use of four composite indicators: Numerical flexibility, degree of decentralisation, structural and individual learning. The composite indicators are all constructed out of several relevant questions in the survey. The four composite indicators will also be used in this paper. They all intend to describe different ways to organise work within a firm.

The choice of indicators in the FLEX-3 study is based on a belief that firms are acting in an environment that change more rapidly every year. This means that their ability to adjust to new conditions have become necessary for economic performance in the short run and survival in the long run. The firms have a higher demand for “just in time” practises and the ability to adjust labour cost when demands change more rapidly.

Various studies of organisational flexibility have looked at the links between numerical and functional flexibility. They have tried to explain how organisations are able to obtain these concurrently.

According to Kalleberg (2001), this link is achieved using the core – periphery model. The core is associated with more regular workers having good employment conditions. The periphery consists of those having a more casual employment relationship. Functional flexibility is concerned with the ability of employees to handle different tasks and move between jobs, i.e. multi-skilling. This approach enables employers to match changing workloads, production methods and/or technology. Numerical flexibility refers to the ability to adjust the number of workers or the number of hours worked, in response to changes in demand. Due to the core – periphery model, a higher degree of temporary employment might not have any relation to work condition outcomes between sexes. Our hypothesis about a working place with a high degree of core employees, having good employment conditions, would have less difference between sexes. We belief that those firms are keen on keeping their best personnel, that is they make no or less differences due to sex. If the periphery employees dominate in the firm we would expect the opposite to be true.

In decentralised firms individuals have more power over their own task and can to a higher degree decide about their working hours. Therefore it would be assumed easier to combine these types of jobs with family-life. But is this type of organisation more equal between man and women or has it just a larger proportion of women than men?

Knowledge sharing is based on the assumption that the knowledge possessed by individuals can be converted into organisational knowledge. Knowledge sharing is perceived as one of the indicators of social capital accumulation in organisations because knowledge possessed by one member of an organisation can be shared easily and efficiently under the condition by which sufficient social capital resides (Collins & Hitt, 2006). That means that firms with a higher degree of structural learning is less dependent on individuals' knowledge as knowledge are assumed to be kept within the firm even if the employee leaves. Therefore we think it would be considered easier for the employer to replace an employee, for example when the employee stay home on parental leave or are caring for sick children, known in Sweden as VAB. It might also be the case that women, who in general have more responsibilities for children, are more attracted to these kinds of organisations. The overall number of days with parental leave and VAB might be higher in such firms, but they are not necessarily more equally split between parents?

The hypothesis of organisations which concerns individual learning is that they are keen to maximise the output of each individual and thereby the differences between sexes may be less concerning career opportunities and income.

Further, one interesting question remaining is whether organisations which delegate power to the individuals, like the decentralised organisations, are more or less sex equal than others.

For more details about the different measures and how these composite indicators are constructed and chosen, please read the summary of Meadow in ”Flex 3, a work in progress” and further about Meadow in “Work organisation and competence development in Swedish firms, based on the Swedish Meadow Survey 2010”[87]

2 Data

Data used in this paper to analyse work organisation is from the Meadow Survey. The Meadow Survey used the same selection as both the survey on ICT use by enterprises in 2009 and the Community Innovation Survey 2008. The telephone interviews took place at the end of 2009 and the beginning of 2010. The total numbers of selected firms was 1 395, of which 21 were no longer active. 881 firms responded the Meadow Survey, and the response rate of 64 percent is considered high for a new voluntary survey.

The four composite indicators measuring different kinds of work organisations composed from the Meadow answers were not always answered by all firms. The number of observations for the composite indicators varies from 767 to 802. For more details see the summary table in Appendix A.

The Meadow Survey covers most of the industries in the private sector. In order for firms to have some kind of thought about work organisation a restriction was made to only include firms with at least 15 employees.

Register data, from the database LISA[88], on both firms and individuals were merged with Meadow data. The main reason to

[87] Nylund (2010)

[88] Integrated database for labour market research includes all firms and individuals above age 15 in Sweden

use LISA was to add information about the employees, such as income, use of parental leave, education level, age and experience.

Problems arose as not all firms in the dataset had employees of both sexes. Even more common was the case of employees who didn't have at least one child aged 0-10 years living at home and therefore no value for measuring the parenthood indicator. Too many firms were lacking data on the parenthood variables, and an imputation of values would have a too strong effect on the outcome. Instead these firms were excluded.

3 Method

In order to analyse the relationship between work organisation and differences between sexes two different methods are used, correlation and ordinary least square, OLS.

Correlation describes the relationship in a straight forward way. But, sometimes you want to go more thorough and isolate the effects from the influence of other factors. In that case you use a regression. Take for example income: women had 86 percent of men's income in the private sector in 2008 according to Statistics Sweden. Another comparison is when analysing equal income for equal work using a regression with control variables. That is adjusting for differences in share of women, age, education level, experience and industry between firms.

A summary table of all variables used with mean figures and number of observations can be found in Appendix B.

3.1 How are differences between sexes measured?

When deciding about how to measure differences between sexes two factors were considered: accessible data and the Swedish Government's aim for the gender and equality policy. One factor that affects women and men to have the same opportunities at work is how the responsibilities for their homes and family are divided. From the LISA database a few but very relevant indicators of such responsibilities were found: numbers of parental leave days and VAB days used by each parent. They are used as proxies to measure how equal women and men share the responsibility as parents, which should have a large impact on their opportunities at work. The differences in the responsibility will in the long run affect other factors as position and income. Still it is important to study these phenomena separately.

For women and men to have the same power to shape society and their own lives it is crucial that income and the share of leading positions equally divided.

Four different variables, parental leave, VAB, position and wages were selected in order to tell something about the differences between men and women in the firm. From those four variables two indicators were created, career and parenthood. Further a total sex differences indicator was composed from the career and parenthood indicator.

3.1.1 Career indicator

Our belief is that an equal firm shall have equal career opportunities and equal representation of women and men in executive positions. The career measure of differences between sexes is a weighted share of income and leading positions. Employees defined as managers according to the International Standard Classification of Occupation, ISCO, are classified as having leading position (ISCO=1).

$$\text{Income quotas}_i = \frac{Abs[Mean\ income\ for\ females_f - Mean\ income\ for\ males_f]}{Mean\ income_f}$$

Where f is short for firm. Income will be measured as the sum of gross salaries, and self-employed income excluded. The income quotas are measured as the absolute value of mean of income for females in the firms minus the mean of income for females in the firms, divided by the mean income for the employees in that firm. The higher the value of the quotas the more unequal the mean income is between sexes.

Leading position indicator is calculated as:

$$\text{Leading position quotas}_i = \frac{Abs[X_f - Z_f]}{\dfrac{Number\ of\ employees\ with\ a\ leading\ position_f}{Total\ number\ of\ employees_f}}$$

Where;

$$X_f = \frac{Number\ of\ female\ with\ a\ leading\ position_f}{Total\ number\ of\ females_f}$$

$$Z_f = \frac{Number\ of\ males\ with\ a\ leading\ position_{if}}{Total\ number\ of\ males_f}$$

Leading position quotas are expressed as the absolute value of share of women with leading positions subtracted by the share of men with leading position within the same firm, divided by the proportion of employees with leading positions.

Income and leading position quotas are combined to a career indicator:

$$\text{Career indicator}_{\text{fi}} = (Income\ quotas * 4)_f + Leading\ position\ quotas_f$$

As mean value for income quotas are lower than for leading position, income quotas were weighted to be as important as Leading position in the model. The mean value for income quotas was 0.26 and the mean value for leading position quotas was 1.00. As the mean value for leading position quotas was about four times as high, income quotas was multiplied by four in the career indicator. This means that differences in each sub indicator has the same impact on the aggregated indicator.

3.1.2 Parenthood indicator

One of the Swedish Government's equality goals is that men and women divide the parental insurance equally. The measure parenthood indicator will in this paper include both parental leave and VAB. The two measurements are somewhat different as days with parental leave usually are planned in advanced and therefore not assumed to effect the firm as much as VAB which cannot be planned in the same way, although some employees with very specific task can be hard to replace for a period even if it is planned in advanced.VAB is defined as the number of net days a parent stays home from work in order to take care of a sick child. Parental leave is measured as number of net days used per individual. Only individuals having at least one child aged 0-10 years are included.

$$\text{VAB quotas}_f = \frac{Abs[Mean\ number\ of\ VAB\ net\ days\ for\ females_f - Mean\ number\ of\ VAB\ net\ days\ for\ males_f]}{Mean\ number\ of\ VAB\ net\ days_f}$$

$$\text{Parental leave quotas}_f = \frac{[Mean\ number\ of\ parental\ leaves\ net\ days\ for\ females_f - Mean\ number\ of\ parental\ leaves\ net\ days\ for\ males_f]}{Mean\ number\ of\ parental\ leaves\ net\ days_f}$$

$$\text{Parenthood indicator}_f = (VAB\ quotas * 2)_f + Parental\ leave\ quotas_f$$

Where f is firm.

As the mean value for the VAB quotas was half the mean value of parental leave quotas, the VAB quotas were multiplied by two in order to be equally important in the parenthood indicator.

3.1.3 Total sex difference indicator

A total sex difference indicator is calculated for each firm. The indicator is based on both the career indicator and the parenthood indicator. As the mean values for the career indicator and the parenthood indicator are quite similar, 2.04 respectively 1.91, equal weights were used. The total sex difference indicator is constructed to measure a combination of career indicator and parenthood indicator. The sex differences indicator is our way of measure the effects on the employees of their one values and attitudes as well of the attitudes in society, in their own families and in the workplaces.

$$\text{Total sex difference indicator}_f = \text{Career indicator}_f + \text{Parenthood indicator}_f$$

3.2 Other things to consider

As said before, you want to take into consideration other things than just work organisation and differences between men and women to be able to say something about work organisation and the difference between the two sexes. You need to run a regression and include control variables. An overview of all variables and indicators constructed are presented in the summary table in Appendix A.

For example, differences in income can be explained by differences in educational level attained, experience and age. Experience is measured as years from highest educational level achieved. As the effect from more experience is dropping for every additional year also, the variable squared experienced is added. When explaining differences in income differences in age between men and women is relevant, whereas differences in parenthood can be explained by differences in mean age in the whole firm, men and women in total, as the attitudes between generations matter.

The European Commission Special Eurobarometer[89] shows how very few men and women aged 15-39 in Sweden believe that "Ideally, women should stay at home to look after children". However, the same picture is not true for individuals aged 40-65, where 17 percent, compared to 7 percent in the younger age group, agreed on the above statement. The hypothesis is that a firm with a higher mean age have bigger differences between sexes and the sex with higher mean age will have the highest income.

The Swedish labour market is highly segregated, that is, women and men work to a great extent with different tasks and in different sectors and industries. To exclude the industry effect, 5 industry dummy variables were included in the model.

Control variables are used in two different ways, either as mean level of men in firms or as differences between sexes in firm. Age, experience and squared experience are used as mean value for male in firms. How the firm is organised would be captured by the share of females in firm f:

[89] EU Commission, 2006

$$Share\ of females = \frac{Abs[mean\ number\ of\ females_f - mean\ number\ of\ males\ _f]}{Mean\ number\ of\ employees_f}$$

The Ordinary Least Squares regression, OLS, model used in this paper:

$$\boldsymbol{Sex\ difference}_{f,} = \propto + \beta_1 * \boldsymbol{Work\ organsiation}_f + \beta_2 * Share\ of females_f + \beta_3 * Mean\ age\ males_f + \beta_4 * Age\ equality_f + \beta_5 * Mean\ experience\ males_f + \beta_6 * (Mean\ experience\ males)_f^2 + \beta_7 * Master\ education\ equality_f + \beta_{8-12} * 5\ Industry\ dummies_f + \varepsilon_f$$

In the model above, seven different ways of measuring sex differences, including four quotas and three indicators, are used as well as four different measures of work organisations. In the Results chapter the coefficients from the four types of work organisation are presented. The complete regression results from the sex difference indicator are found in Appendix C.

4 Results

In order to analyse if different types of work organisations can explain any of the differences between sexes in a firm we use both correlation and regression models. In contrast to the correlation the regression model "takes care" of firm differences due to employee composition and differences due to type of industry which we want to exclude when analysing work organisation differences. The correlation outcome and complete regression results for sex difference indicator, including Adj-R^2 and number of observations, are presented in Appendix B and C.

An overview of results from the OLS-regressions is put together in Table 1. The dependent variables are shown on top, vertically, and the four different kinds of work organisation composite indicators, used as explanatory variables in the model are presented to the left. Every unique combination of equality indicators and work organisation indicators are from a separate regression. That is, every single coefficient, cell, in Table 1 is picked from a unique regression and describes the effect from different organisations on differences between sexes. Control variables are included in every regression, but not presented in the table. For the total equality indicator the whole regression is exposed in Appendix C.

The work organisation indicators have value set from zero to one, where one indicates max flexibility. For the indicators of differences between men and women in the firm value zero indicates non difference, that is: the larger the differences between sexes the higher the value for the sex differences. This means that a negative sign in the table indicates that the more the firm is flexible, the less the differences are between sexes.

Table 1
OLS-regression with dependent variables: Sex differences measured by four different quotas

	VAB	Parental leave	Leading position	Income
Numeric flexibility	-0.6***	-0.2	-0.8***	-0.1**
Decentralisation	-0.2*	0.2	-0.2	0.0
Individual learning	-0.2**	0.0	-0.3***	-0.0
Structural learning	-0.3*	-0.0	-0.4**	-0.0

Where *** indicates significance at the 1% level, ** significance at the 5% level and * significance at the 10% level. Control variables included in all models: share of females, mean age of males, age equality, mean experience of males, squared mean experience of males, experience equality, master educated equality and 5 dummy variables for industry.

The overall interpretation of Table 1 is that all significant values are negative. This implies that the higher the value of the four composite indicators for work organisation, the lower the sex difference, measured by quotas, is in the firm. In other words, different kinds of work organisation are overrepresented in firms with less difference between sexes.

The strongest effect was found in organisations with a higher degree of numeric flexibility. More numeric flexible firm were overrepresented among firms having a more equal use of VAB days and division of leading positions. Therefore you might draw the conclusions that core employees' good working conditions dominate over the periphery employees in more flexible firms. However there is one exception in the correlation table. Mean income is marginally more different between sexes in firms with a higher degree of decentralisation. After controlling for individual specific factors between firms no differences in income remained, except in numeric flexible firms where differences were lower.

In more decentralised firms a tendency to more equal split of VAB days was found. Sex differences concerning parental leave, leading position and income was however not found in more decentralised firms. When individuals have more power over their own tasks and working hours, as in decentralised firms, the sex differences is not any different than in other firms. That is, when individuals are free to choose, they choose more traditionally.

Type of organisation could not explain differences in parental leave days used by men and women. They were about the same no matter organisation.

In the second table, Table 2, the sex difference quotas are combined into three indicators: a parenthood indicator, a career indicator and a total sex difference indicator. The parenthood indicator is based on VAB and parental leave, whereas the career indicator is based on income and leading position. The total sex difference indicator is "not surprisingly" a total indicator of sex differences and a combination of the parenthood indicator and the career indicator.

Table 2
OLS-regression with dependent variables: indicators for sex differences

NY	Parenthood indicator	Career indicator	Total sex difference indicator
Numeric flexibility	-1.4***	-1.2***	-2.5***
Decentralisation	-0.3	-0.1	-0.3
Individual learning	-0.4*	-0.4***	-0.7***
Structural learning	-0.6	-0.5*	-1.1**

Where *** indicates significance at the 1% level, ** significance at the 5% level and * significance at the 10% level. Control variables included in all models: share of females, mean age of males, age equality, mean experience of male, squared mean experience of males, experience equality, master educated equality and 5 dummy variables for industry.

In Table 2, the dependent variables from Table 1 are presented in more aggregated forms, indicators. The regression results are robust and the overall picture remains the same using indicators instead of quotas. However, the effects get stronger due to more significant coefficients.

Firms with a higher degree of numeric flexibility, individual as well as structural learning all have less differences between sexes. Decentralised organisation, where employees are left with more control over their own working conditions are neither more nor less sex equal than firms less decentralised. This could be interpreted that impact on sex differences is stronger when a firm makes a statement of the firm's attitude towards parenthood, rather than in more decentralised firms where the individuals are more entitled to make the decisions on their own. Leaving the decision to parents might result in more conservative pattern with more unequal responsibilities for children.

In Appendix B the correlation results between sex differences and work organisation are presented. The results are more or less the same as in the regression models: firms with a higher degree of numeric flexibility, individual learning and structural learning have a negative correlation with more sex unequal firms. All significant values indicate the same thing. The only exception is a significant positive relation between unequal income and decentralisation in the correlation matrix. When control variables are included in the regression model that effect is gone.

The equal results from regressions and correlations implicates that differences between sexes remain/are the same after controlling for factors as differences in employee character and industry differences.

One of the independent control variable used in the model was the share of females in the firm. The variable turned out negative in the childhood indicator regressions and positive in the career indicator regressions. That means that in firms organised with higher proportions of females, the employees had a more equal use of VAB and parental leave days. The opposite was true for share of females and the career indicator: the higher the share of females the more unequal was the income and share of females in leading positions.

5 Concluding remarks

In this study our attention has not been to analyse any of the gender differences when it comes to: the power, the roles and other traditionally gender equality aspects of the work places. Instead we have tried to capture the outcomes or impacts of these and other conditions in society and at workplaces. We have studied the relationship with this outcome indicator of sex differences and work organisations.

Our results showed that different types of work organisation significantly can explain sex differences. Firms with less differences between the sexes are overrepresented among those with a higher degree of numeric flexibility, individual and structural learning. Firms that are more or less decentralised are not different from other firms concerning differences between the two sexes.

Can it be that the effect of the core employees, with better working conditions, in numerically flexible organisations dominates above the periphery employees with a more casual employment situation? That is, caring for employees includes trying to diminish the sex differences? We do not know the answer to that.

For firms with more of individual learning there were findings indicating less difference between sexes. A firm keen on upgrade employees' knowledge seems also to be keen on reducing differences between sexes.

Firms with a higher degree of structural learning are less dependent on their employees' knowledge as the knowledge is assumed to be captured by the firm. However, the results indicate that these kinds of organisations do not have a larger proportion of women with higher family responsibilities, but on the contrary having smaller differences between the sexes.

When individuals have more power over their own tasks and working hours, as in decentralised firms, they were assumed to be able to combine their jobs with family life. The results indicate that leaving the parental leave and VAB decision to the individuals do not shows any significant effect on the differences between the two sexes.

A higher share of women among the employees resulted in a more equal use of VAB and parental leave days within the firm. The opposite was true for the career indicator, where a higher share of women led to a more unequal power distribution as the income discrepancy rose and share of women in leading positions was reduced.

The overall conclusion is that when the individuals have more influence over their own working conditions, they tend to follow traditions to a greater extent rather than when new things are imposed on them from the organisation. Especially firms that have a high degree of numeric flexibility have more clear staff strategies that they carry out. This seems to diminish the differences between sexes.

We hope that these results are of interest on their own terms. However perhaps of equal importance; they could serve as a kind of mapping of areas of interest for gender equality research. This research could unfold differences in power: roles and other traditionally gender equality aspects of the work places and give new insights to our findings.

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APPENDIX A, Summary table

Firm level	Mean	StDev	N
Total sex difference indicator	3.96	1.81	591
Career indicator	2.04	1.03	591
Parenthood indicator	1.91	1.37	591
VAB quotas	0.47	0.55	591
Parental leave quotas	0.97	0.73	591
Leading position quotas	1.00	0.74	591
Income quotas	0.26	0.14	591
Share female	0.29	0.16	591
Numeric flexibility	0.30	0.13	802
Decentralisation	0.43	0.23	795
Individual learning	0.64	0.33	767
Structural learning	0.73	0.17	821

APPENDIX B, Correlation

NY	Numeric flexibility	Decentral-isation	Individual learning	Structural learning	Share of female
VAB	-0.15***	-0.10**	-0.11**	-0.15***	-0.07*
Parental leave	-0.04	0.01	-0.03	-0.05	-0.20***
Leading position	-0.11***	-0.04	-0.15***	-0.10**	0.22***
Income	-0.07	0.11**	-0.02	0.03	0.37***
Parenthood indicator	-0.14***	-0.08*	-0.11**	-0.15***	-0.17***
Career indicator	-0.12***	0.01	-0.14***	-0.08*	0.37***
Total equality indicator	-0.17***	-0.04	-0.16***	-0.15***	0.08**
Share of female	0.06	0.09**	0.01	0.04	1

APPENDIX C, Results from OLS-regressions

Dependent variable; Total sex differences indicator

Number of Observations Read	881
Number of Observations Used	495
Number of Observations with Missing Values	386

Root MSE	1.69302	R-Square	0.0751
Dependent Mean	3.84893	Adj R-Sq	0.0502
Coeff Var	43.98688		

		Parameter Estimates			
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	8.02495	1.82027	4.41	<.0001
NUMERIC FLEXIBILITY	1	-2.53717	0.61185	-4.15	<.0001
Share of female	1	1.18522	0.51762	2.29	0.0225
Mean age male	1	-0.06488	0.04087	-1.59	0.1131
Age fem./male	1	-3.17506	1.22248	-2.60	0.0097
Mean experience male	1	0.12859	0.10355	1.24	0.2149
(Mean experience male)^2	1	-0.00163	0.00267	-0.61	0.5431
Experience fem./male	1	0.70653	0.41196	1.72	0.0870
Master educated fem./male	1	0.06611	0.03733	1.77	0.0772
Base manufacturing Industry	1	0.08525	0.22425	0.38	0.7040
Manufacturing Industry	1	-0.40793	0.26195	-1.56	0.1201
Energy Industry	1	-0.39194	0.31310	-1.25	0.2113
Trade Industry	1	-0.11794	0.30293	-0.39	0.6972
Manufacturing machinery Industry	1	-0.30749	0.25016	-1.23	0.2196

Dependent variable; Total sex differences indicator

Number of Observations Read	881
Number of Observations Used	479
Number of Observations with Missing Values	402

Root MSE	1.70715	R-Square	0.0464
Dependent Mean	3.85675	Adj R-Sq	0.0197
Coeff Var	44.26407		

		Parameter Estimates			
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	8.33362	1.83900	4.53	<.0001
DECENTRALISATION	1	-0.33708	0.36198	-0.93	0.3522
Share of female	1	0.86836	0.52520	1.65	0.0989
Mean age male	1	-0.07514	0.04075	-1.84	0.0658
Age fem./male	1	-3.41081	1.22574	-2.78	0.0056
Mean experience male	1	0.11834	0.10410	1.14	0.2562
(Mean experience male)^2	1	-0.00124	0.00273	-0.46	0.6484
Experience fem./male	1	0.63130	0.41650	1.52	0.1303
Master educated fem./male	1	0.03103	0.03926	0.79	0.4297
Base manufacturing Industry	1	0.02300	0.23502	0.10	0.9221
Manufacturing Industry	1	-0.46621	0.26935	-1.73	0.0841
Energy Industry	1	-0.44599	0.31718	-1.41	0.1604
Trade Industry	1	-0.33276	0.30728	-1.08	0.2794
Manufacturing machinery Industry	1	-0.40836	0.25753	-1.59	0.1135

Dependent variable; Total sex differences indicator

Number of Observations Read	881
Number of Observations Used	452
Number of Observations with Missing Values	429

Root MSE	1.73689	R-Square	0.0701
Dependent Mean	3.88938	Adj R-Sq	0.0425
Coeff Var	44.65729		

Variable	DF	Parameter Estimates: Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	7.39343	1.95513	3.78	0.0002
INDIVIDUAL LEARNING	1	-0.74711	0.26405	-2.83	0.0049
Share of female	1	1.19270	0.55825	2.14	0.0332
Mean age male	1	-0.09266	0.04370	-2.12	0.0345
Age fem./male	1	-2.63928	1.28484	-2.05	0.0406
Mean experience male	1	0.22183	0.11042	2.01	0.0452
$(\text{Mean experience male})^2$	1	-0.00314	0.00284	-1.10	0.2704
Experience fem./male	1	0.86495	0.43314	2.00	0.0465
Master educated fem./male	1	0.10671	0.05113	2.09	0.0374
Base manufacturing Industry	1	-0.21956	0.24720	-0.89	0.3749
Manufacturing Industry	1	-0.75868	0.29071	-2.61	0.0094
Energy Industry	1	-0.46982	0.33062	-1.42	0.1560
Trade Industry	1	-0.31682	0.31241	-1.01	0.3111
Manufacturing machinery Industry	1	-0.53372	0.27439	-1.95	0.0524

Dependent variable; Total sex differences indicator

Number of Observations Read	881
Number of Observations Used	499
Number of Observations with Missing Values	382

Root MSE	1.70384	R-Square	0.0439
Dependent Mean	3.85553	Adj R-Sq	0.0183
Coeff Var	44.19217		

		Parameter Estimates			
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	7.83302	1.82029	4.30	<.0001
STRUCTURAL LEARNING	1	-1.12030	0.51027	-2.20	0.0286
Share of female	1	0.92291	0.50981	1.81	0.0709
Mean age male	1	-0.07021	0.04056	-1.73	0.0841
Age fem./male	1	-2.56976	1.20453	-2.13	0.0334
Mean experience male	1	0.12705	0.10152	1.25	0.2114
(Mean experience male)^2	1	-0.00125	0.00263	-0.48	0.6340
Experience fem./male	1	0.51762	0.41379	1.25	0.2116
Master educated fem./male	1	0.06322	0.03853	1.64	0.1014
Base manufacturing Industry	1	-0.00742	0.22714	-0.03	0.9740
Manufacturing Industry	1	-0.47874	0.26483	-1.81	0.0713
Energy Industry	1	-0.31676	0.31315	-1.01	0.3123
Trade Industry	1	-0.23285	0.30665	-0.76	0.4480
Manufacturing machinery Industry	1	-0.27943	0.25300	-1.10	0.2699

The impact of working conditions

Hans-Olof Hagén Statistics Sweden[90]

Not about working conditions but about impact

The term working condition is normally used in studies of employees. These studies are based on data gathered by interviews and questionnaires to individuals. The individuals are asked for information of their subjective perception as well as of objective facts. Since we have only used the Meadow employer questionnaire in our study and not the employee questionnaire we do not have this kind of data. However, what we do have is register data on employees. This will give us great opportunities in the future. Of course this will still not allow us to measure the working conditions but will allow us to measure the impact. With the impact we mean the probability of sickness leave, the job status and the career development of the employee in the coming years. The objective of our study is to find indicators of the impact, which gives interesting results in itself but also is a kind of mapping of interesting research areas. If the working conditions are good we expect the sickness leave to decrease, the probability of working at the same firm some years later to increase and the career development to improve. Our hypotheses is: the decentralised firms and also the firms that are good at individual respectively structural learning have better working conditions, while we are hesitant about the numerically flexible firms. These hypotheses are based on our earlier studies the Flex-1 and Flex-2 as well as on the literature.

Five different categories of job status

We will first look into the job status development. The job status development can be categorised into two possible scenarios. In the first scenario the employees continue to be employed also in the coming years. This implies that the employee is employed within the same firm but also that he/she has found employment in

[90] I am in great dept to Caroline Ahlstrand Statistics Sweden and Marina Aksberg Stockholm University who made most the calculations for this paper.

another firm. If the working conditions are good both the ability of the employees and their desire to keep their job will increase. It is of course also a positive outcome if they have got a new job at another firm. This could of course be a negative indication of the attractiveness of the old job including the working conditions, but on the other hand the employees were attractive enough to get a new job that could indicate the opposite relationship.

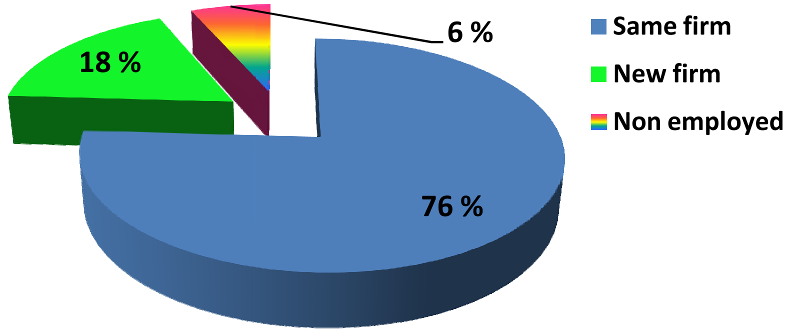
The second possible scenario is that they are out of job a few years later. This development of their job status is definitively a negative outcome of the working conditions. That some have reached the normal retiring age three years later and are no longer working is of course not a negative sign of the working conditions, although an increasing number of white collar workers in Sweden who are above 65 continue to work, at least part time, for another year or two. This group who have retired at 65 years of age have been excluded from our dataset and is not used as observations in the calculations. In the next step, all remaining observations are split into three different mutually exclusive categories.

What data we would have liked to have, and what we actually have

The data that we had wished for is the organisational data year t_0 and the register data on the job status some years later. Unfortunately this is not the case. However, we have register data for year t_{-1} and t_{-4}, in this case for year 2008 and 2005, since our organisation data are from 2009 year t. When these data are used they are based on the implicit assumption that most firms have kept their organisation and work practises relatively unaltered from year 2005 up to year 2009 (the year of the survey). This means that we use 2005 as year t. One finding that backs up this assumption is that most organisations did not change that much between 2007 and 2009, see the paper by Martina Aksberg and Lana Omanovic about the quality of the Meadow data[91]. Starting from the firms that did answer the questionnaire 2009/2010, these have been followed back to 2005. Most of the firms existed in 2005. In the second step, those working in these firms in 2005 have been tracked to 2008, and their job status has been registered and split into the different categories that have been described earlier.

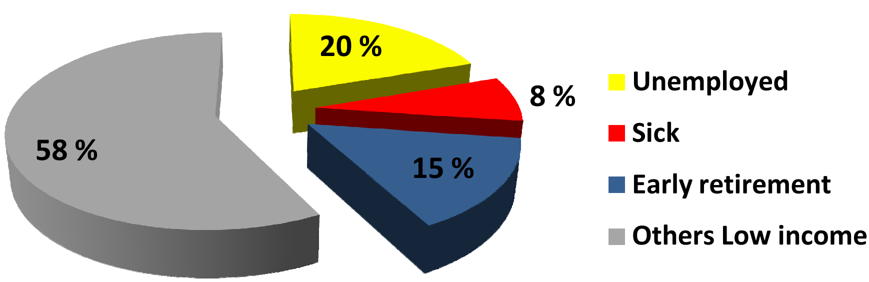
[91] Lana Omanovic, Statistics Sweden and Martina Aksberg, Stockholm University."Quality of data in the Swedish Meadow Survey"

Figure 1
The job status 2008 for the Meadow employees 2005



First the Meadow employees from 2005 are split into three categories: Those who have kept a job at the same firm[92] up to 2008 make up the vast majority, since three quarters of them are found in this group. The second largest group comprises those who got a job at another firm in 2008; they are three quarters of the rest or 18 percent of the total number. That means that those who are in the third category make up between 6 to 7 percent of the employees in Meadow firms in the year 2005.

Figure 2
The non job group split into subcategories



[92] These individuals are linked to a firm in November 2008.

Those out of a job are in turn split into four groups: the unemployed[93], the sick[94], those who retired early[95] and the rest[96]. As can be seen in figure 2 the last group is the largest one with three out of five observations within the non-employed category belonging to it. Those on unemployment benefits comprise the second largest and make up another fifth of the non job group. Those who retired early are about twice as many as those on sick leave, or 15 respectively 8 percent. Finely the last group consists of the rest, who probably live on social security or with their relatives.

Our hypotheses

The basic hypothesis is that a more flexible work organisation leads to better working conditions. In turn, better work conditions create less stress and mental strain in general. This should lead to less sick leave in the short and the long term. Overall, flexible work practices should keep people in the job to a higher degree than other organisational forms.

However, it seems that firms that are on the forefront in human resource strategies not only value most of their employees but are also good at separating themselves from the employees who they do not consider to be very attractive. So our hypothesis for the job status development is that this factor will take over.

Substantial differences in probabilities to keep or get a new job

We will start with analysing the correlation between the work organisation indicators and the different groups of non job status from figure 2. The first finding that is evident is that none of the flexibility modes give a significant probability to preserve jobs or to increase the employees' probability to get a new one. However, it is important to take into account two facts: the implicit assumptions that the work organisation in most cases is unaltered during a four to five year period and those firms that did not make it to 2008 were in fact excluded.

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[93] Those who had at least on third of their income 2008 in form of unemployment benefits.

[94] Those who got sickness benefits for at least 60 days.

[95] Those who have received a pension for early retirement.

[96] Those who are in none of the other 5 categories. All of them had a total income of less than EUR 14 000..

Table 1
The correlation between individuals' job situation 2008 and flexibility

	Numeric Flexibility	Decentrali-sation	Individual learning	Structural learning
Probability of keeping one's job	-0.01	-0.01	-0.01	0.04
Probability of getting a new job	-0.02	0.02	0.01	-0.03
Probability to be on unemployment benefits	0.02	-0.01	0.02	-0.07 *
Probability to be on sick leave	-0.04	-0.05	-0.00	-0.07 *
Probability to have retired early	0.05	-0.08 *	0.05	0.03
Probability to be outside the labour market	0.10 **	-0.01	0.00	0.01
Probability of no job	0.08 *	-0.04	0.02	-0.03

In the paper on the long-term effects[97] it is clear that the probability of closures is significantly lower in decentralised firms and in firms that are good at individual learning. This is important since a closure substantially increases the risk for vulnerable employees to be out of job. Still, those working in numerically flexible firms in 2005 have a slightly higher probability to be out of job in 2008. This seems to be because these firms seem to dispose of people to a larger extent so they fall outside the labour market to a higher degree. The only other facts that stand out are that the decentralised firms have fewer employees that retire early, and the firms that are more involved with structural learning have fewer former employees that are on unemployment benefits or on sick leave.

Large differences in the chance to have a job

However, there are large age differences, gender differences and education and experience differences in the risk of being out of job. There are also substantial differences due to geography and industry. When studying table 2 one has of course to be aware of the fact that this is just based on the firms included in the Meadow Survey that have existed already in 2005. On the other hand there are no systematic biases besides that only firms with at least 15 employees are included, and some industries that are not represented in the innovation survey are thus not in the Meadow Survey. However, the noise or random error is rather high since the number of persons included is only around 100 000 out of 3 million

[97] Hanna Wallén: "Organisation and Long-term Firm Development"

working in the private sector. Still, most differences are probably rather similar to those found in the total labour force in the business sector in Sweden.

In table 2 the probabilities for different groups to have kept their jobs or got a new one under the time period 2005 to 2008 is displayed. The young people who are those who are up to 35 years of age have a 10 percent lower probability to be in the same firm three years later compared to older ones since their odds ratio is 1.1. However, they also have a little higher, also 10 percent, probability to be working in another firm than those over 35 years of age. These differences are as expected but perhaps a little low.

Also in line with what was expected the low-educated employees, that is, those with less than a secondary education, are less inclined to have a job at the same firm three years later. The high-educated employees with at least a three year university degree have around 60 percent higher probability (0.7/1.2=0.58) than those with less than a secondary education to be working in the same firm three years later. This means that crises have had a knowledge biased impact on the labour market. The difference is lower when it comes to getting a job in a new firm. Given that the yardstick is employees with a secondary education up to those with a short university exam, the differences are not that large. Still this means that the younger employees are not more likely to get a job at a new firm than the highly educated ones irrespective of age.

Table 2
The probability to have a job 2008

	The probability to be in the same firm as 2005	The probability to be in another firm than 2005
Young	0.9	1.1
Low education	0.7	1.0
High education	1.2	1.1
Men	0.9	1.3
Immigrants	1.1	0.8
Stockholm	1.5	0.8
Large cities	1.3	0.8
Rural areas Private	1	1.0
Rural areas Public	0.6	1.9

Corrected for work experience and Industry. All coefficients that differ from 1 are significant.

The difference between the two sexes in mobility is even more striking. Men seem to have a 30 percent higher chance to get a new job and are 10 percent less likely to keep their old one compared to women. Our perception is that immigrants have a much weaker position on the Swedish labour market compared to native Swedes. However, those who already had a job in 2005 actually kept it to a somewhat higher degree. Although this has to be seen together with their rather low mobility in order to get the full picture. So it is perhaps less voluntary for them to stay at the same firm as it also seems to be the case for the women.

Apparently the regional centres and medium sized cities, which have been used as the regional yardstick in our regressions, were the most turbulent geographical areas in these years, together with the local communities located in the countryside, especially those with few business jobs. They deviate significantly from development in the larger cities. This is probably explained by the sharp drop in manufacturing jobs in 2008 which was more evident in these areas.

The risk of being out of a job differs considerably between groups

If we look at the other side of the coin we will get more or less the opposite of the result already presented, since the employees in the Meadow firms in 2005 either have a job in 2008 or they do not have one. Still, there are a lot of interesting details to be found.

The relatively young ones have the same probability to be out of job as those who have passed 35 years of age. It even looks as they have had a higher probability to have lost their footing in the job market completely. This is probably due to fact more of them have not qualified for unemployment benefits and have to live on social security. Fortunately they are much less likely to be retired early, in their case very early. However, a probability of more than one third (0.4) of the older ones is quite high, since that implies that the employees who are over 35 have just 2.5 (0.4/1=2.5) times higher probability to retire early compared with the younger ones.

Table 3
The probability to be out of a job 2008

	Probability to be unemployed	Probability to be on sickness leave	Probability to have retired early	Probability to be outside the labour market	Probability of no job
Young	0.9	1.2	0.4	1.6	1
Low education	2.7	2.4	2.9	2.2	2.6
High education	0.4	0.4	0.5	0.9	0.9
Man	0.7	0.6	0.7	0.8	0.7
Immigrant	2.2	1.4	2.3	1.2	1.5
Stockholm	0.3	0.6	0.4	0.7	0.7
Large city	0.6	0.7	0.7	1	0.8
Rural areas Private	1.2	1.3	1.1	1.4	1.7
Rural areas Public	1.4	1.2	1.1	0.7	1.2

Corrected for work experience and Industry. All coefficients that differ from 1 are significant.

Education is definitely something that splits the water and has a huge effect on the outcome as expected. The low-educated Meadow employees have more than twice as high a probability to fall into every one of these out-of-job categories compared with those who have a secondary and post secondary education up to a short university education. Compared to those with a long university education, the probability is even four to six times higher. However, there is one exception to this rule and that is the risk of falling out of the labour market completely and to rely on social security or relatives. This probability is almost as high for those with a long university education than others. One possible explanation is the fact that these people tend to have a longer unemployment period and a higher percentage of long term unemployment due to a much higher degree of specialisation.

There is also a marked gender difference; the risk to be unemployed, sick, early retired and outside the labour market for men is just two thirds of this risk for women. This underlines the need for policy directed at diminishing these differences. Immigrants comprise another underprivileged group with a much higher risk of losing their jobs or becoming sick, and in particular to have to retire early. The only exception is the probability of the immigrant group to be left without any means of income other than social security. For those who had a job in the Meadow firms in 2005 the risk was not that much higher than for the Swedish born colleagues. However, this figure is for those who had a job at the Meadow firms in 2005 and does not include those who never have made it into the labour market in the first place.

Finally, geography also plays a role here. Rural areas with weak labour markets suffer more and the large cities are not that badly hit. One very interesting observation is that it seems that both the probability of being on sickness benefits and to become retired early is linked to the situation of the labour market in each category of local communities.

The relative probability of firm Z

All these individual differences shown in table 2 and 3 have to be taken account of. Thus a regression has been estimated for the average probability for each category of Meadow employees to fall into a certain job status category 2008.

These probabilities have then been aggregated into an estimated average percentage for each firm. That means that in a certain firm the estimated probability given the staff composition from 2005 to be outside the labour market in 2008 is X percent. If the actual percentage instead is Y percent, the index for this firm is Y/X. If this index number is larger than 1 this firm has an above-the-average number/probability of its staff that have left the labour market between these years. First, it has been tested if these index numbers are positively or negatively correlated with the indicators for the different composite indicators of flexibility.

Table 4
The correlation between non-job and flexibility

	Numeric Flexibility	Decentrali-sation	Individual learning	Structural learning
Relative probability to be on unemployment benefits	0.2	0.0	0.07 *	0.01
Relative probability to be on sick leave	-0.04	0.03	-0.03	-0.07
Relative probability to have retired early	0.06	-0.01	0.08 *	0.06
Relative probability to be outside the labour market	-0.01	0.01	0.02	-0.01
Relative probability of no job	0.01	0.01	0.06	0.01

As can be seen in table 4 the number of significant relationships has dropped considerably when the influence of all these other factors has been accounted for. The indicator for non job is not significantly related to any of the flexibility modes. However, the firms that have a lot of individual learning have a significantly higher value of unemployment and early retirement. Still, we have to go on to regression analyses where we remove the effects of industry, firm seizes and regional category to isolate the relationship to work organisation of 2008.

Still, the picture seems quite unaltered. The lack of relationship to no job for the organisational indicators is even more profound, and the individual learning is linked to unemployment and early retirement. However, the structural learning is now also linked to a higher probability of early retirement for their 2005 employees, which was not the case earlier.

Before going into any interpretation, we first want to repeat the two basic reservations mentioned earlier about the implicit assumptions about constant work practices for five years and that we do not take account of the effect from the firms that are forced to close down between 2005 and 2008. We also have the problem with the crisis in 2008 that could have hit individual firms within an industry differently.

Having said that, the first hypothesis that flexible firms have better working conditions which should contribute to a smaller probability for their employees to be out of jobs was not confirmed. The second hypotheses of duality of the more advanced firms when it comes to human resource management was confirmed, since the firms that are good on learning also seem to be good at getting rid of less attractive employees in the form of early retirement.

Table 5
The relation between non-job and flexibility

	Numeric Flexibility	Decentrali-sation	Individual learning	Structural learning
Relative probability to be on unemployment benefits	0.6	-0.0	0.6 **	0.2
Relative probability to be on sick leave	-1.0	0.9	-0.2	-1.5
Relative probability to have retired early	1.7	-0.2	1.1 *	2.0 *
Relative probability to be outside the labour market	0.1	0.0	0.2	0.2
Relative probability of no job	0.2	0.1	0.3	0.2

Controlled for industry, region and firm size. * =10 percent level of significance, **=5 percent and ***=1 percent.

The relationship between long term sickness and work organisation

The term long term sick leave means that the measurements are based on register data from the social insurance agency that handle sicknesses that are longer than two weeks. The indicator is the mean number of sickness days per person or firm. The measurement problems are not at all as large for this indicator as the earlier treated. As is clear from Lana's and Martina's paper on the quality of our organisational data[98] that the organisational layout was in most cases relatively unaltered between 2007 and 2009 and when our register data is from 2008 it is more or less a cross section dataset we have. However, the relationship between work organisation and working conditions on one hand and the sick leave is probably a long term relationship with a substantial time lag. In order to get this kind of data a repetition of the organisation survey is necessary, followed up with register data for the following years.

Table 6
The correlation between long time sick leave and flexibility

	Numeric Flexibility	Decentrali-sation	Individual learning	Structural learning
Sick leave	0.10 **	-0.14 ***	-0.01	

The same kind of estimation on individuals has been done for this indicator as for the job status probabilities, and that for the same reason: the large differences between different categories of people due to age, education, gender and so on. The numerically flexible firms have a staff structure that has a significantly higher risk of long term sick leave, while all the other flexibility modes have a significantly lower probability. The final indicator that will be used is the relation between the normal estimated percentage sick leave and the actual for each firm (X/Est(X)).

Let us first look at the correlation matrix in table 7. Here the firms those are more numerically flexible stand out. They are the only ones that have a significant and positive relationship with sick leave. That means that even if their negative staff structure is taken account of they still have quite significantly higher sickness leave.

[98] Lana Omanovic, Statistics Sweden and Martina Aksberg, Stockholm University."Quality of data in the Swedish Meadow Survey"

This can be seen as an indicator of their worse working conditions than the average firm. All the other coefficients are negative, although not always significant. In the case of the more decentralised firm, if their positive employee composition is taken into consideration, their sick leave is no longer significant on the 10 percent level, only on the 20 percent level.

Table 7
The correlation between long term sick leave and flexibility

	Numeric Flexibility	Decentrali-sation	Individual learning	Structural learning
Relative probability for sick leave	0.14 **	-0.07 (*)	-0.04	

In a regression where it is controlled for the influence of industry and region, these relationships are intact. The indicator for working conditions still tells the story of not so good working conditions in the numeric decentralised firms. And there is a tendency for the indicator to point in the other direction for the other flexibility modes, in any case for the decentralised firms.

Table 8
The relationship between long term sick leave and flexibility

	Numeric Flexibility	Decentrali-sation	Individual learning	Structural learning
Relative probability for sick leave	-2.7***	-0.8(*)	-0.4	-0.4

Controlled for industry and region

However, this difference does not seem to influence the job status as far as it could be measured with the data we have access to just now. The only indicator which points in this direction is that the highest coefficient for early retirement is the one for the numerically flexible firms.

The conclusion was in this case more or less confirmed. The suspicion that the working conditions in the numerically flexible firms could be somewhat problematic and that there is a strong tendency in a positive direction for the decentralised firms are in line with expectations. The positive relationships with the learning modes could of course have been much stronger, but it must be taken into account that we in the best case had just cross section data so far.

Flexibility and careers

Good work organisations should not only diminish the negative impact of working life. They should also strengthen the resources of the employees so they can grow more in knowledge and competence than they otherwise would have done. An indicator of this could be their income development. Our hypothesis is that employees working in more decentralised and learning firms have a better income development. If we just calculate the average income increase for the employees in each Meadow firm we will not get an unbiased result since the staff composition varies a lot and should be adjusted for to make a meaningful comparison. We know that the normal income developments differ between age groups and education levels, the young and highly educated have in general higher income increases.

The employees in the Meadow firms are split into three age and two incomes groups. The age groups are the same as earlier: up to 35, over 35 but under 50 and those who are 50 years of age and older. The education groups are two: those who have a secondary education or less and those who have more than a secondary education. In total they make up six groups. For each group an estimation of the income development from 2005 to 2008 have been estimated. The variables that have explained the income development in the regression have been: experience, sex, ethnicity, regional type and industry. The differences between the individual income developments and the estimated ones have been normalised by dividing this difference with the standard deviation of the respective group they belong to. This means that a certain income increase, X percent, is worth more if that group in general has had relatively small income increases and the other way around. For each firm the normalised average income increase Z is calculated.

$$(1) \qquad Z_k=(\sum(X_i-EstX_i)/sd_j)/n_k$$

Z is our relative normalised income development indicator
k is the firm indicator
X is the income development between 2005 and 2008
EstX is the estimated the income development between 2005 and 2008
sd is the standard deviation for each of the six age-education groups
i are the employees in this firm
j are the six groups

When a correlations table is constructed in order to test/see if there are any relations between these normalised average income developments and the different flexibility modes.

Table 9
The correlation between normalised average income developments and flexibility

	Numeric Flexibility	Decentralisation	Individual learning	Structural learning
Normalised average income development	-0.02 ***	0.07 ***	0.05 ***	0.03 ***

The results are very conclusive. The employees in the numerically flexible firms have got a less than average income development while the employees in the decentralised firms and learning firms, both individual and structural learning, have got a larger than average increase. All four coefficients are very significant. To test if these relationships depend on industry and region, regressions have also been estimated for all four flexibility moods. As can be seen in table 10 all these relations were confirmed.

Table 10. Income developments explained by flexibility

	Numeric Flexibility	Decentralisation	Individual learning	Structural learning
Normalised average income development	-0.03 ***	0.02 ***	0.01? ***	0.01 ***

Controlled for industry and region

Our hypothesis was confirmed in three cases and the outcome was as we suspected in the last case. Good work organisations should give the employees better resources so they can grow more in competence and ability than they otherwise would have done. This should come out in their income development, so employees working in more flexible firms should have a better income development. This also means that numerically flexible firms are not that good for their employees in this aspect. As a matter of fact they are worse than the average firm.

Conclusions

Analysis of the impact of work organisations should be based on long time series with substantial time lags between the observed work organisation and the resulting impact on other variables. And in the best case they should be backed up with employee surveys. Still, we have tried to test some hypotheses with the help of primarily cross section data and based on the assumption on unaltered work organisation for at least a three to four year period. These results indicate that the hypothesis that decentralised and learning firms have better working conditions which in turn should result in a smaller probability for their employees to be out of jobs was not confirmed. The second hypothesis of duality of the more advanced firms when it comes to human resource management was confirmed, since the firms that are keen on learning also seem to be good at getting rid of less attractive employees in form of early retirement.

The hypothesis that good work conditions decreases stress and other negative impact on the employees that should result in a decreased sick leave and less good conditions would increase sick leave was not confirmed in a very conclusive way. The decentralised firms showed an almost significantly negative relationship with sick leave already with cross section data and the two learning modes had negative signs. On the other hand the numerically flexible firms had higher sick leave also after corrected for the higher risk among their employees.

Finally we also tested if the relative income development was significantly higher among the decentralised and learning firms and significant lower for the numeric flexible firms. These hypotheses were confirmed.

Our general conclusion, even if the data is far from an ideal dataset, is that in any case decentralised and probably also the learning firms have better working conditions while the numerically flexible firms do not. However, this is no guarantee for how the more employee friendly organisations deal with their less attractive employees.

In spite of the fact that the data was far from ideal, we received some interesting results. Apart from the interest in itself, these findings could also be used as indicators of appealing research areas for in-depth research based on subjective and objective data on individuals.

Organisation and Long-term Firm Development:

A panel study for Swedish firms

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Abstract

In this paper the long-term relationship between organisation and productivity is explored. Productivity is measured both in level and growth terms for the period of 11 years. We find that firms with higher degree of decentralisation and individual learning on average have higher levels of labor productivity and these differences are persistent over the period of analysis. On the contrary no significant relationship between organisational characteristics and productivity growth has been found. Finally, individual learning and decentralisation seem to increase to a firm's chance to survive.

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1 Introduction

It is difficult to overrate the meaning of good organisation. It improves performance on an individual level as well as of a company on the whole which makes organisation of great interest for both individuals and companies giving jobs to different kinds of consultants and coaches. While personal organizing is, at least theoretically, rather clear, efficient organizing of a firm might be quite complicated. Suitable organisational structure enhances productivity which is in turn crucial as a mean to attain economic growth, improvement of working conditions and standards of living. The source for productivity growth is seen in technological change and innovation as well as in organisational change and learning on the other hand (Eriksson, 2003).

Efficient organisation is therefore of considerable interest for management as well as policymakers. A number of studies on the significance of organisational change and innovation, learning strategies and flexibility have been developed and carried out, once or regularly, both on the national level and internationally comparable: DISCO in Denmark every fifth year, IAB in Germany and PASO in Belgium annually, EPOC in Europe in 1996, EFE in France in 2004-2005, ESWT and CIS in Europe every four years (Grid Report: State of the art in surveys of organisational change, MEADOW background document No2).

Surveys which give data comparable for different countries and over different periods of time represent the highest value for researchers and policymakers. For this reason the MEADOW survey has been designed to be carried out in the European countries, and the ambition is to repeat the survey regularly.

The notion of flexibility is much referred to in the MEADOW framework as well as in the previous surveys and studies (Asplund, Oksanen, 2003; ITPS, 2001). Flexibility is seen as vital for the firm's adaptation to the rapidly changing environment, for innovative activities and improving performance. Human resource development strategies are used to achieve labor flexibility. In the literature practices enhancing flexibility are called new work organisations (OECD, 1996), high-performance work organisations (Appelbaum et al., 2000) and this subject is widely researched in the literature and variety of ongoing projects.

There are good possibilities to study organisation in Sweden and the other Nordic countries due to the availability of economic register data for all the firms. Studies of workplaces called FLEX and FLEX-2 were undertaken in Sweden in 1991 and 1998 respectively. The FLEX-3 project in Sweden and a similar project based on MEADOW framework in Denmark are in progress.

It is important that the methodology used to interpret and analyze the results of the survey is integrated between the countries-participants. The Swedish FLEX-3 team has been working to develop valid and robust indicators of organisational capabilities to use in the analysis. This paper is meant to link the previous Swedish survey FLEX-2 with FLEX-3, being an attempt to adapt the measurements of FLEX-3 to the data from the FLEX-2 survey. The special aim of the analysis in this paper is to determine the relationship between firms' organisation and productivity over a longer period of time.

When it comes to the studies on productivity in the long run, the majority of them is conducted for an industry or macro level. This is due to the fact that in most countries firm-level panel data includes observations on a small sample of firms or is not available (Dearden, Reed, Van Reenen, 2006). Statistics Sweden possesses firm-level register data for all the firms year after year, which makes it possible to conduct the analysis at the firm-level.

Next come some clarifications on the terms used in the paper.

In this paper organisation is considered as a structure that is planned and managed in order to achieve certain goals, rather than as a social or cultural phenomena. Organisations from private and public sector are included in the analysis as long as financial data is available for them, meaning that they are engaged in economic activity. Such organisations are referred to as "firms" in this paper.

A firm is seen as a group of people, tasks and objects united for the purpose of achieving a common goal. The most common goals include economic and social performance (The MEADOW Guidelines, 2010). Economic performance denotes increases in productivity, sound financial state, successful innovation and survival on the market. Social performance yields secure employment, the quality of jobs, health and work-life balance.

The paper is organized as follows. Section two provides some insights into the theory of organisation, particularly different types of organisational flexibility, along with the ways to categorize different organisational characteristics. Section three describes the data used. Section four provides the empirical model. And the last two sections cover the results of the analysis, conclusions and suggest possible future development in the area.

2 Background

Theoretical base of the analysis in this paper is comprised by economic growth theories on one side and organisational theories on the other. In this section these theories are reviewed and systematized. Then the intuition behind the indicators and their construction are described along with the hypotheses about their relation to productivity.

2.1 Theoretical framework

General interest in economic growth and its factors resulted in developing of growth theories. First of them were concerned with explaining differences in wealth and growth between countries.

In the model developed by R. Harrod and E. Domar the factors of economic growth include level of saving and capital productivity, which were taken as exogenous. This model states that there is no reason for a balanced growth of the economy. Solow and Swan then extended Harrod-Domar model by including labor as a factor of production as well as technology improving with time. In their model, also referred to as neoclassical growth model, economic growth is still exogenous and determined by the rate of technological progress. This model is still widely used to estimate the separate effects of technological change, labor and capital on economic growth, mostly on the macro level. The main criticism of the neoclassical growth model was concerned with likely endogeneity of its factors. Jacob Schmookler investigated endogenous nature of technological innovation using patent data at an industry level and found technological progress to be not barely supply-pushed (Schumpeter, 1934), but also demand-pulled. Nathan Rosenberg criticized the common view of "technological phenomena as events transpiring inside a black box" (Rosenberg, 1982). This problem was addressed by Robert Lucas and Paul M. Romer by means of endogenizing technological change, which resulted in the development of endogenous growth theory in the 1980s. This theory brings the interest to the mechanics of technological change, the source for which is found inside the firms as human capital. Though still addressing the macro level (sectors, countries), endogenous growth theory justifies the interest in work organisation as a potential resource of productivity growth.

The development of the growth theories reflecting growing focus on the factors internal to the firm logically leads us to the set of organisation theories that make up the ground for this research and are discussed below.

It is difficult to denote the one and only founder of organisation theory as we know it today and I am not going to do that. Some of the concepts of organisation theory (management, leadership) can be traced already in works of Greek philosophers Plato and Aristotle. It is wise to name the work of Adam Smith (1994 [1776]), in which along with numerous other ideas the enormous benefits of labor division and specialisation for productivity are described using pin manufacturing as an example.

Karl Marx is regarded as one of the founders of sociology as well as organisation theory (Hatch, 2006) with his theory of capital and idea of alienation of workers from the product of their work. Moreover, Nathan Rosenberg argues that "Marx' analysis of technological change opened doors to the study of the technological realm through which hardly anyone has subsequently passed" (Rosenberg, 1982, p.viii).

Another important set of concepts of organisation theory are Max Weber's ideas on authority and bureaucracy. He differentiates between traditional and charismatic authority and argues that with industrialization another form of authority was created – rational-legal authority. Bureaucracy, according to Weber, rationalizes the social order in a way similar to technology's rationalizing of economic order. This idea led to the common today view that organisational structure may promote technical efficiency.

Frederick Winslow Taylor is another significant contributor to the development of organisation theory, particularly industrial management. Based on his experience from being a chief engineer at a steel producing company as well as experiments, Taylor developed procedures to stimulate efficiency and productivity of factories. These procedures included work standards, uniform work methods, skill-based job placement, supervision and incentive schemes (Hatch, 2006) and together formed the scientific management system. According to this system, research and experiments were used to find ways to lower production costs while paying high wages. The drawback of scientific management as put by Taylor is looking for "one best way" with no regard to environment or changes necessary for development.

Works of Joseph A. Schumpeter were of great importance for the development of organisational studies, particularly the concepts of innovation and entrepreneurship. Innovations are determined by Schumpeter as endogenously driven processes of change. Competition and entrepreneurship are the drivers of innovations which in turn drive long-run evolution of the economic system. Schumpeter distinguished between five types of innovations: product, process, market, input and organisational innovations.

Early work of Schumpeter (1934) suggests that evolution of the economic system is driven by the new firms created by innovative entrepreneurs. Later, in "Capitalism, Socialism, and Democracy" (1950), entrepreneurship is seen as "collective": large corporations innovate or imitate the others thus causing change in the population of firms trough transformation, selection, births and deaths. The "collective" entrepreneurship determines which forms of organisations survive and which do not, which is basically the concept of evolutionary economics.

Richard Nelson and Sidney Winter (1982) expanded Schumpeter's and others' ideas and developed "an evolutionary theory of the capabilities and behavior of business firms". The firms are confronted with complex environment where they are not able to take into account all the information and there for cannot act rationally. The firms have certain "capabilities and decision rules", which develop over time and are heterogeneous over firms. The environment deselects actors, capabilities and decision rules not fit for survival, reducing the variety. New variety of capabilities and decision rules is created through random effects and/or designed innovations.

While the classical theory of organisation was concerned with finding a universal best way to organize, evolutionary and contingency theories turn attention to the context of the firm. Therefore, the most appropriate organisational structure depends on a number of factors: scale of operation, technology, market and environment. Moreover, Giovanni Dosi and Richard Nelson argue that in highly uncertain conditions caused by technological advances and the nature of markets and competition "there is no way that a truly optimal policy can be even defined, much less achieved" (Dosi, Richard, 2009, p.28).

Finally, we should keep in mind the firm's function of minimizing transaction costs, both between the members of the firm and in contacts with environment.

2.2 Measurement framework

The system of indicators used in this study and by the Swedish FLEX-3 team was and developed on the base of the experience from FLEX-1 and FLEX-2 projects and MEADOW framework.

The motivation for this system of indicators is the importance of flexibility for positive organisational development, especially in the modern economy which is characterized by increasing competition, redundancies, closures and mergers and high degree of uncertainty.

In this situation the organisation's ability to adapt, or flexibility, is of great importance.

The most popular definition and classification of organisational flexibility were presented in the work of John Atkinson (1984), who differentiates between the following types of flexibility: numerical, functional and financial.

Numerical flexibility concerns adjustment of the labor input which can be implemented in firing and hiring employees on temporary or part-time basis (external numerical flexibility) and regulating number of working hours among the employees (internal numerical flexibility). The aim of numerical flexibility is to reduce costs of adjusting labor input to the demand, and the possible methods of achieving this are using services of work agencies and outsourcing.

Functional flexibility allows the employees to alter between the functions within the firm. This type of flexibility requires training of the employees to achieve versatility and in-depth knowledge of the firm's processes.

Financial flexibility implies that wages and other labor costs reflect the performance of the employees and the firm on the whole. It is achieved by applying individual wages or performance based pay systems.

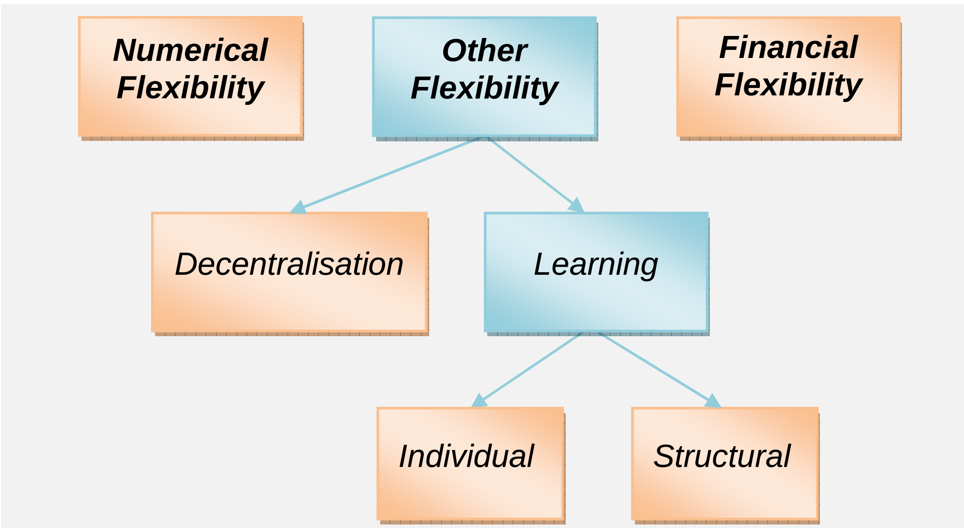
Atkinson described the structure of a firm's employees as concentric parts, instead of hierarchical structure. In the very center of the firm is a group of key employees. They perform different roles and functions concerning the firm's main activities and are in return offered a long-term commitment and career growth. This core usually includes top-management, designers and technicians and contributes to functional flexibility. The employees belonging to outer concentric parts have a looser bond with the company. The first peripheral group might include full-time employees performing specific jobs, these employees are not expected to move horizontally or vertically within the firm. The second peripheral group includes employees with fixed-term and/or part-time contracts, coming from work agencies and allows for numerical and functional flexibility.

Next comes the description of indicators constructed and used by the whole FLEX-3 team and particularly in this paper.

The indicators used by the Swedish FLEX-3 team, while resemble Atkinson's view of flexibility, put additional attention to learning strategies. Composition of the indicators for the FLEX-3 project has been described by A. Nylund in "Firm's work organisation and competence development in Sweden".

The system of flexibility indicators used in this paper is presented on figure 2.1.

Figure 2.1
Composite indicators of flexibility



Numerical and other flexibility[99] of firms are determined based on the information available from the survey. Numerical flexibility in the context of FLEX-3 project refers to the employees' possibilities to rotate between different tasks, shares of part-time and temporary employment, as well as share of employees and hired from work agencies. These components represent both internal and external sources of numerical flexibility. All these factors are likely to be good proxies to the firm's ability to vary the input of labor at a low cost.

Other flexibility is considered to be implemented by the means of decentralisation and learning. Decentralisation indicator is meant to a certain degree to cover functional flexibility, since the employees should have skills of multitasking in order to work in a decentralised organisation. High decentralisation implies that the

[99] Use of the term 'other flexibility' by FLEX-3 team is motivated by the deviation of this concept from functional flexibility as put by John Atkinson (1984).

employees have great degree of freedom in planning their own work, are engaged in team-work and have flexible working schedule.

Nicholas Bloom et al. name three main benefits from decentralisation (Bloom, Sadun, Van Reenen, 2010). The first benefit is reduced costs of information transfer and communication. In decentralized decision making information is processed at the same level where it is used, reducing the cost of communication. Second, decentralisation gives greater flexibility, expressed in speed of response to market changes, at the same time requiring multitasking of workers. The third way decentralisation may increase productivity is raising job satisfaction through greater involvement of lower-level staff. There are also potential costs that might be caused by decentralisation. First, with high degree of decentralisation the risk of duplicating information induces higher costs of its processing. This in turn leads to higher probability of mistakes with less coordination. Third, decentralisation and multitasking may eliminate economies of scale. Finally, Bloom et al. point out the risk of reducing workers' efficiency and work satisfaction due to increased stress caused by more responsibility. Given the benefits and costs of decentralisation named it is not easy to predict expected effect of increasing the degree of decentralisation. According to contingency theory, depending on the conditions, certain benefits will prevail over the costs. Therefore I am going to control for size and industry in the analysis.

Including implementation of learning practices in the analysis is justified by the learning economy hypothesis and the concept of lifelong learning. The learning economy hypothesis explains speed-up in the rate of change by increasing global competition and rapid diffusion of new technologies (Lundvall, Johnson, 1994). Capacity to learn is therefore critical for the performance. Other research finds increase in demand for highly skilled labor in the learning economy (e.g. Caroli, Van Reenen, 2001; Bresnahan et al., 2002). Lifelong learning is an important attribute of learning economy with its high rate of technological change. The employees need to continuously upgrade their knowledge and skills under the pressure of increasing competition on the labor market due to globalisation and ageing of population. Nielsen and Lundvall (2003) also note the change in the nature of knowledge use: knowledge is not used more intensively, but "becomes obsolete more rapidly than before" (Nielsen, Lundvall, p.3).

In the FLEX-3 project the concept of learning is decomposed into individual and structural learning. Individual learning refers to competence development of the employees by means of training and education. The result of this process is development of human capital, which is positively related with economic growth at the system level according to endogenous growth model (Romer, 1990). We expect individual learning to stimulate productivity on the firm level as well. The indicator is meant to capture both formal and so called "tacit" knowledge, including questions on education as well as learning in daily work.

While individual learning is related to the employee's competence, the result of structural learning can be detached from employees and refers to the development of the firm's practices for employees, product or service development, production and quality control. In Argyris and Schön (1978) learning involves the detection and correction of error. They differentiate between single-loop and double-loop learning. Single-loop learning is characterized by taking the goals, values, frameworks and, to a significant extent, strategies as predetermined. Double-loop learning involves modification of organisation's underlying norms, policies and objectives. Argyris (1990) argues that double-loop learning is necessary to make informed decisions in rapidly changing environments and under conditions of uncertainty. Firm's flexibility is the capability necessary for the modifications in the process of double-loop learning.

Exploring structural learning particularly was not among the goals of FLEX-2 survey, therefore the questions concerning implementation of structural learning practices are scarce. Even though the indicator of structural learning is constructed based on the information available it is not clear if it may be relied on.

The FLEX-2 survey contains information about share of employees whose wages are based on the individual or team performance criteria. This information is used to construct the indicator of financial flexibility.

A general index of flexibility can be calculated as the sum of all four indicators, but in this paper the indicators are treated separately with the intention to study each one of them in relation to firm's productivity.

For the purpose of this paper the indicators have been constructed with respect to the information available from FLEX-2 survey although the ambition was to construct the indicators as close as possible to those used in the FLEX-3 project. Each indicator is composed of several components. The components in most cases take on values 0 or 1. The value of 0 denotes that a certain practice or learning strategy is not implemented in the firm or is implemented to a very low degree. The composite indicator is calculated as the sum of its components to make the interpretation of the regression results more accessible.

Table 2.1 summarizes the components of the indicators. A table with complete questions that have been used to construct the indicators is included in the Appendix.

Table 2.1
Construction of the composite indicators

Indicator	Values
Numerical flexibility = NF1+NF2+NF3+NF4	**[0, 2.79]**
Share of part time employees	NF1: [0, 1]
Share of temporary employees	NF2: [0, 1]
Share of recruited employees	NF3: [0, 1]
Rotation	NF4: 0 or 1
Decentralisation = D1+D2+D3+D4	**[0, 4]**
Schedule flexibility	D1: 0 or 1
Daily and weekly planning by individual	D2: 0 or 1
Quality control and follow-up of results by individual	D3: 0 or 1
Team participation	D4: 0 or 1
Individual learning = IL1+IL2+IL3	**[0, 3]**
Learning in daily work	IL1: 0 or 1
Feed-back	IL2: 0 or 1
Share of employees that participated in paid education	IL3: 0 or 1
Structural learning = SL1+SL2	**[0, 2]**
HR-development plan for every employee	SL1: 0 or 1
Follow up external ideas	SL2: 0 or 1
Financial Flexibility = FF	**[0, 2]**
Individual wage criteria	

Due to the fact that FLEX-2 had a theoretical and methodological framework slightly different from MEADOW's, it was not possible to construct indicators identical to those used in FLEX-3. For example, there were found only two out of seven components for the indicator of structural learning. Other questions imply answer yes of no in FLEX-2 and a quantitative answer in FLEX-3. The composite indicator of numerical flexibility best matches the one in FLEX-3 due to the objective character of its components. The indicator of decentralisation is missing information about the number of organisational levels and quantitative information about team-work. Individual learning indicator is missing information about non-paid education and proportion of employees participating in on-the job training. On the whole however it is reasonable to assume that the indicators in this paper measure about same characteristics as those used in the FLEX-3 project.

3 Data and descriptive statistics

Several data sources have been merged for the purpose of the analysis. The primary source is the survey data from FLEX-2 project, which was carried out in 1997-2000 by NUTEK, Swedish National Board for Industrial and Technical Development. The aim of the project was to study the links between work organisation and productivity, in particular the significance of new management strategies including different learning strategies for the profitability and productivity of enterprises. For being non-obligatory, the survey yielded high response rate of over 70 percent (2937 out of 4000, details in Table 3.1).

Table 3.1
Distribution of response indicator, FLEX-2.

Response indicator	Frequency	Percentage	Cumulative
Only questionnaire	14	0,48	0,48
Only telephone interview	1252	42,63	43,11
Both	1671	56,89	100,00
Total	2937	100,00	

The survey was conducted in the form of a small or large questionnaire and telephone interview. The distribution of the methods is shown in Table 3.2.

Table 3.2
Methods of data collection, FLEX-2

Method of data collection	Frequency	Percentage	Cumulative
Large telephone large quest	1543	38,58	38,58
Large combined quest	405	10,13	48,70
Small combined quest	721	18,02	66,72
Small questionnaire	138	3,45	70,17
Only telephone interview	1193	29,82	100,00
Total	4000	100,00	

There are 4000 observations in the survey to start with. For the purpose of this research it is needed that the respondent had answered both large telephone interview and large questionnaire. Thus sample is reduced to about 38 percent of the respondents who answered all questions of interest for this research.

Reorganisations taking place during the period of analysis make an obstacle in creating the panel data set. Although absolute majority (over 90 percent) of the firms go through the analyzed period of 11 years without reorganisations, some 3-4 percent of the firms in the sample divide or merge with another firm.

In order to follow eventual reorganisations of the firms year to year the FAD-database has been used, FAD being acronym for Swedish "Firms and Workplaces Dynamics" (Företagens och Arbetsställenas Dynamik). This database is aimed to create firms' identities that can be followed over time, even if the corporate identity number has been changed or a division or merger has taken place. The condition for the firm to keep its identity for two consequent years is the following: a group of same employees should be employed at the firm in the two years, and this group must comprise majority (more than 50 percent) of total number of employees. This principle does not satisfy the purpose of this study completely. In some sectors of economy firms usually have high turnover of employees (restaurants, trade), thus while FAD gives such firms a new identity every year we would want to keep those firms as the same. In these cases, such firms were kept in the analysis as same if the correspondence of the firm's name and corporate identity number was verified.

Each firm in the sample is given a unique identity index. In case of division the data is aggregated over the newly established firms. If a merger occurred the id is transferred to the consolidated firm.

The survey data is then merged with database containing information about all firms in Sweden including physical capital, sales, value added, number of employees and wages. Companies from financial sector are excluded due to the specific character of their activity and accounting. Only firms with 5 or more employees are considered in the analysis, leaving us with an unbalanced panel with 1159 observations in 1998, which by 2008 reduced to 1050. There are 1237 unique units of analysis, 887 of which are present in all the 11 time periods.

To account for heterogeneity across industries, the sample has been divided into groups by two-digit SNI[100] or NACE-code (NACE is an acronym for French "Statistical Classification of Economic Activities

[100] SNI stands for Svensk Näringsgrensindelning. Full classification may be found at http://www.scb.se/Pages/List____257409.aspx.

in the European Community”). In order to avoid very small groups some of them have been merged with similar industry groups.

Table 3.3
Distribution of the observations by industry group

	Industry group	Codes in SNI 2002	Number of observations	
			1998	2008
1	Food manufacture	15	39	37
2	Textiles, leather manufacture	17, 19	13	8
3	Wood manufacture	20	18	16
4	Paper production, publishing	21, 22	45	44
5	Chemicals, rubber, plastic manuf.	24-26	51	45
6	Basic metals, mining and fuel	13-14, 23, 27-28	92	78
7	Machinery	29	59	55
8	Electrical and optical equipment	30-33	44	38
9	Transport equipment	34-35	37	36
10	Other manufacture	36	20	15
11	Construction	45	97	87
12	Trade	50-52	204	190
13	Hotels and restaurants	55	34	28
14	Transport, storage, communication	60-63	80	74
15	Post, TV, radio	64	85	92
16	Real estate, renting business	70-74	157	130
17	Education, health and social services	80, 85, 90-93	84	77
	Total		1 159	1 050

As the table shows, some of the industries are underrepresented (textile, leather and wood manufacturing, hotels and restaurants) and others comprise larger proportion of the sample (trade, real estate and renting business). The distribution is to a great extent preserved over the whole period of analysis. In an attempt to get somewhat smoother distribution of the sample an alternative division has been made. Following the division made in the report on FLEX-2 study the firms are divided into six groups: capital-, labor- or knowledge-intensive manufacturing respectively services. Table 3.4 shows the classification.

Table 3.4
Sector breakdown

	Manufacture	Service
Capital intensive	Pulp, paper and paper products industry, steel and metal manufacture, quarrying and petrochemical industry, and nuclear fuel industry	Real estate, renting business, transport and communication, postal services
Knowledge intensive	Machinery, electrical, communications and transport equipment, chemical industries, publishing	Industrial services, recreation, telecommunications, education, research and development; health and medical care
Labor intensive	Food, textiles, wood products, rubber and plastics, non-metallic mineral products and other manufacture	Wholesale and retail, hotels and restaurants, refuse collection and disposal, other services, construction

Source: Enterprises in Transition, ITPS, 2001.

The next table shows distribution of the observations across the sectors in 1998 and 2008. The first and the last years are chosen in order to show the change of the industrial structure of the sample over the analyzed period of time. The lower figure in each cell gives the percentage share of the respective sector in the sample.

Table 3.5
Sector breakdown in the first and last time-period

Sector		Year	
		1998	2008
Manufacturing	Capital intensive	118	104
		10,18	9,90
	Knowledge intensive	176	162
		15,19	15,43
	Labor intensive	124	106
		10,70	10,10
Service	Capital intensive	237	204
		20,45	19,43
	Knowledge intensive	130	136
		11,22	12,95
	Labor intensive	374	338
		32,27	32,19
	Total	1 159	1 050

The table shows quite even distribution with each of the sectors well represented in the sample. The sector structure is preserved over the period of analysis.

Breakdown by size has been made into three size-groups: 5-49 employees, 50-249 employees, more than 250. Table 3.5 shows the distribution of the observations across different size-groups in 1998 and 2008. Again, the lower figure in each cell gives the percentage share of the respective group in the sample.

Table 3.6
Size breakdown in the first and last time-period

Size-group by number of employees	Year	
	1998	2008
5 – 49	226 19,50	250 23,81
50 – 249	330 28,47	263 25,05
> 250	603 52,03	537 51,14
Total	1159	1050

As the table shows, large firms prevail in the sample, taking up about half of it over the period of analysis.

The variables have been treated to smooth out outliers: observations with negative value added are dropped; value added is further censored to fit in the interval between 1 and 80 percent of gross production. The nominal values of gross production, value added and capital assets have been deflated with respective deflators on 2-digit industry level.

The resulting data set is an unbalanced panel (with gaps) containing information on organisational characteristics referring to 1997 and originating from the FLEX-2 survey matched with economics data on the firm level for the period of 1998 to 2008.

4 Method and model

There is no universally accepted measure of productivity. OECD manual on measuring productivity lists several main productivity measures based on different types of input and output measures used. Types of input measure include labor, capital, capital-labor of capital-labor-intermediate inputs. On the side of output, productivity can be measured based on gross production or value added. From another perspective, productivity can be measured in level or growth terms. Both productivity level and rate of change are important factors of development.

Two measures of productivity are used in the analysis: labor productivity and multifactor productivity growth.

Labor productivity is measured as ratio of value added to labor input. While number of hours worked is the best measure for labor input, for the purpose of this analysis labor input has been measured as total number of employees, and then labor productivity is calculated as value added per employee, with consideration to the data available.

The indicator used to measure rate of change of productivity is gross production multifactor productivity growth (sometimes referred to as total factor productivity). Multifactor productivity is used to measure technical change and overall efficiency of the use of the resources.

In the classic representation of Cobb-Douglas production function ($Y = AK^{\alpha}L^{\beta}$), A denotes total factor, or multifactor, productivity. It includes all the factors, other than labor and capital inputs, that influence output.

More generally, multifactor productivity is expressed as average product of all inputs, or ratio of the output to an index of inputs (Chambers, p.235).

$$MFP = \frac{y}{X}, \tag{1}$$

where y is output, X is the index of inputs.

To get the equation in growth rates, both sides of (1) are differentiated logarithmically with respect to time:

$$\mathrm{MFPG} = \dot{\mathrm{y}} - \dot{\mathrm{X}}, \tag{2}$$

where a dot over a variable denotes the logarithmic derivative with respect to time:

$$\dot{\mathrm{y}} = \frac{\mathrm{d}\ln \mathrm{y}}{\mathrm{dt}}. \tag{3}$$

Growth rate of the index of inputs is specified as cost-share weighted average of the time rates of change of the individual inputs:

$$\dot{X} = \sum_j \frac{w_j x_j}{c} \dot{x}_j, \tag{4}$$

Here, $\frac{w_j x_j}{c}$ is an input's share in gross production. The inputs include labor, capital and intermediate inputs, the latter being equal gross sales minus value added. The share of intermediate inputs is calculated as 1 minus shares of labor and capital, assuming constant returns to scale: $w_I = 1 - w_L - w_K$.

Multifactor productivity growth is then calculated as following:

$$MFPG = \dot{Y} - w_L \dot{L} - w_K \dot{K} - w_I \dot{I} \tag{5}$$

In order to determine significance and magnitude of the response of productivity level and growth to the different organisational characteristics as expressed by the indicators described earlier, regression analysis is used.

Two sets of equations are estimated, one with productivity level (log of value added per employee in real prices) as dependent variable, another with multifactor productivity growth.

The composite indicators are included in the model as explanatory variables together with capital variable, industry or sector dummies and firm's size expressed as size group or logarithm of the number of employees. Capital variable is not included in the equations with multifactor productivity growth as dependent variable to avoid multicollinearity (capital input is used in the construction of multifactor productivity growth). Different model specifications are tested to check the robustness of the results.

The data set constructed represents an unbalanced panel containing on average of 1101 observations per year over 11 years, with an average of 9.8 observations per firm.

To start with, the equations are estimated using pooled ordinary least squares estimation, then with time series estimator (generalized least squares), and at last mixed effects maximum likelihood estimator is used to account for the fact that some of the variables (composite indicators) have fixed values over time while economic variables change.

Next section explores the relationship between organisational characteristics and labor productivity, discusses differences between sectors and at last presents the results of regression analysis.

5 Results

5.1 Stylized facts

In this section the relationship between the indicators and wages and labor productivity is investigated. As it has been stated, FLEX-2 survey does not provide sufficient data on structural learning, so I explore the link between numerical flexibility, degree of decentralisation and individual learning on one hand and labor productivity and wages on the other hand. By looking at the relationship over the whole time period analyzed I implicitly test if the combination of learning strategies applied at a point in time can be assumed to persist over longer time period: the data on learning strategies and flexibility available from FLEX-2 survey refer to 1997, while the period observed is 1998-2008.

Generally, we would expect learning strategies such as decentralisation, individual and structural learning have positive effect on the level of productivity. Secondly, we expect a firm more active in learning to have higher expenses on employees, for example to pay for education. Labor productivity on the graphs is median value added per employee for the firms with a particular value of the indicator in the given year. Wage per employee on the graphs is median wage per employee including social and other expenses. Since wage in this analysis is considered from the firm's side as labor costs, the nominal values have been deflated using production price index by the 2-digit industry level.

I start the analysis of the data by looking at correlation coefficients between measures for productivity level and growth rate and the composite indicators. In table 5.1 correlations statistically significant at 5 percent level are marked with a star and are in bold. While labor productivity levels Log(VA) and most organisational characteristics have statistically significant correlations of magnitude varying from -0.053 for numerical flexibility (NF) to 0.104 for decentralisation (D), most of the indicators have no significant correlation with multifactor productivity growth rate (MFPG).

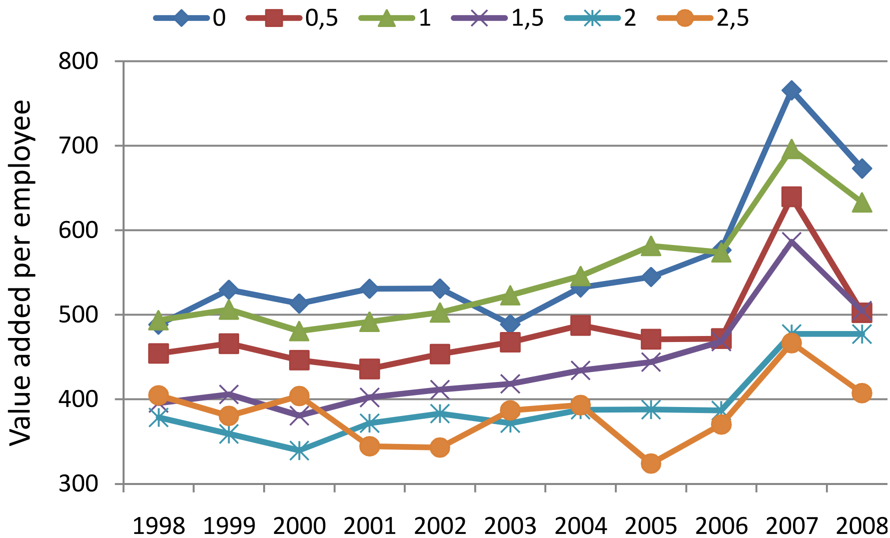
Table 5.1
Correlations between productivity and composite indicators

	Log(VA)	*MFPG*	*NF*	*D*	*IL*	*SL*	*FF*
MFPG	0,197*	1					
Num.Flex.	-0,053*	0,007	1				
Decentr.	0,104*	0,000	-0,009	1			
Ind.Learn.	0,066*	-0,020*	0,129*	0,107*	1		
Str.Learn.	0,002	0,001	0,002	0,078*	0,311*	1	
Fin.Flex.	0,053*	0,002	0,039*	0,127*	0,228*	0,121*	1

I proceed by examining the differences in productivity levels and wages with respect to different values of organisational indicators over time. The composite indicators coming from the FLEX-2 survey refer to 1998, and the ambition is to assess long-term relationship between productivity and organisation. The concern is if it is reasonable to use the indicators measured at one point in time for this kind of analysis, or in other words, is it possible to assume that organisational characteristics of the firms are persistent over time. Not having organisational data available from the later periods, the possible solution is to test this hypothesis implicitly. This is done by looking for persistence of the relationship between the composite indicators and productivity. I also look at the relationship between organisation and wages per employee, and the patterns are similar to those for labor productivity and are shown at figure A.1.

Figure 5.1 shows the development of labor productivity for firms with different degree of numerical flexibility. The values of the indicator are rounded to the closest number with a step of 0.5. Only three firms have rounded value of numerical flexibility indicator equal 3, and from year 2001 only two of those exist. Only five firms have rounded value of numerical flexibility indicator equal 2.5. It seems suitable to unite these small groups into one. Still, a group containing so few observations cannot be regarded as representative.

Figure 5.1
Labor productivity and numerical flexibility. Labor productivity measured as value added per employee, 1000 SEK, current prices



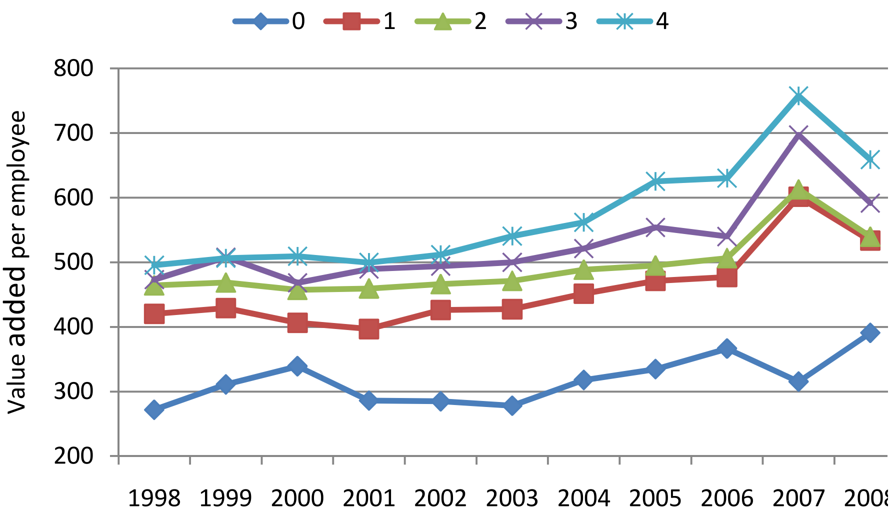
As can be seen from figure 5.1 firms with lower degree of numerical flexibility tend to have higher labor productivity (except for the values of 0,5 and 1), and this difference is generally persistent over the whole period of analysis.

Figure A.1 shows similar graphs for wages and the composite indicators. A generally negative link between numerical flexibility and wages per employee is observed. One of the explanations is the following: high numerical flexibility means that the employees can easily switch between tasks if needed, great proportion of them is hired from an agency, works part-time or has a temporary contract. This usually implies that little specific skills are needed to perform the work. Indeed, if we look at the average values of numerical flexibility by industry group in Table A.1, the highest value of numerical flexibility indicator is observed in the group "Hotels and restaurants", where the share of low-skilled employees is high.

Figure 5.2 shows how labor productivity is distributed by different degrees of decentralisation. Each line corresponds to a certain value of the indicator of decentralisation.

The 10 firms with lowest value of the indicator of decentralisation have substantially lower labor productivity, though a reliable statement cannot be made based on such a small number of observations. Still a clear positive link between degree of decentralisation and productivity is observed for the other firms and this relationship is preserved over time.

Figure 5.2
Labor productivity and decentralisation. Labor productivity measured as value added per employee, 1000 SEK, current prices



Higher degree of decentralisation implies that the employees have higher power and more responsibility, which seems likely to reflect in higher wages. This is confirmed by figure A.1, and the differences in wages are also persistent over time.

Positive and highly persistent relationship is observed between the value of individual learning indicator and labor productivity (figure 5.3).

Figure 5.3
Labor productivity and individual learning. Labor productivity measured as value added per employee, 1000 SEK, current prices

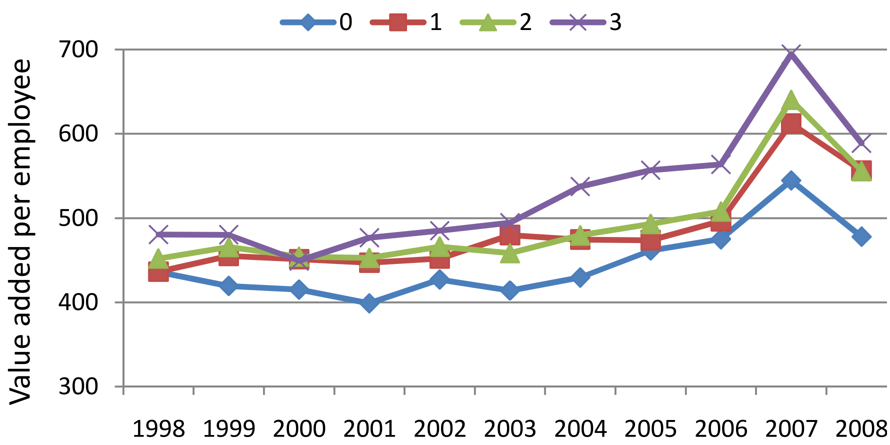
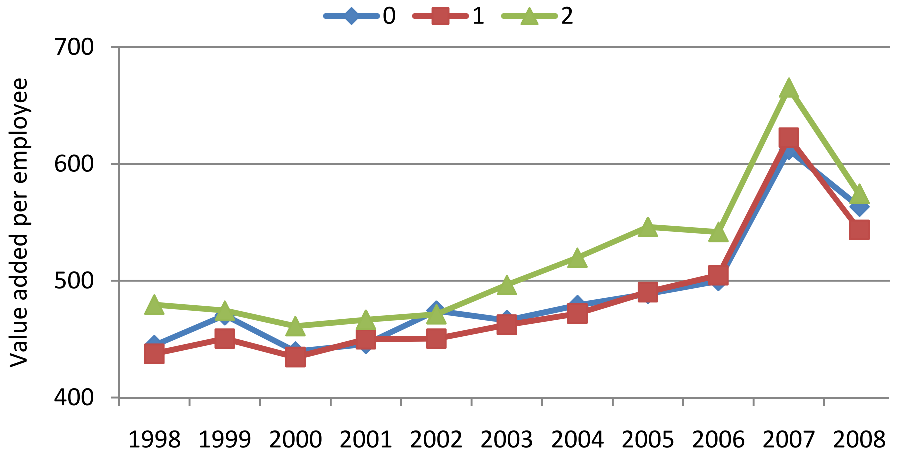


Figure 5.4 shows the relationship between structural learning and productivity. Slightly higher productivity is observed for the firms with the highest degree of structural learning, while implementing only one of the two components of structural learning does not seem to have any effect on productivity.

Figure 5.4
Labor productivity and structural learning. Labor productivity measured as value added per employee, 1000 SEK, current prices



The data suggests presence of more or less significant and persistent differences in productivity and for varying organisational characteristics as measured by the indicators used. While the relationships confirm the expectations, it could be the case that the differences originate from the firms belonging to different industries. Next section explores this issue, looking at the relationship between sectors and organisational indicators.

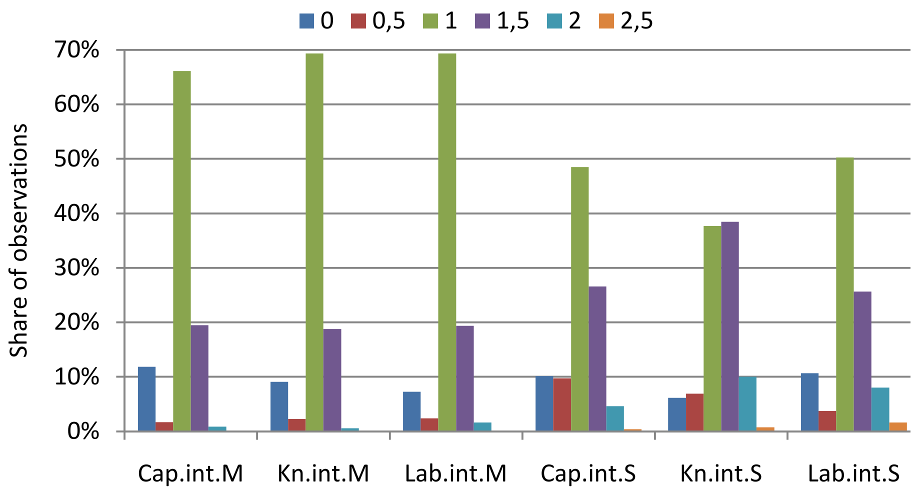
5.2 Exploring sectoral differences

When performing analysis of firms operating in different economic branches, it is necessary to account for peculiarities of the various industries. In this paper, the industries are grouped into six sectors (table 3.4).

The report based on FLEX-2 survey "Enterprises in Transition", explored differences of organisation between the sectors of economy, finding for example that firms in knowledge intensive manufacture and service sectors were more likely to have human resource development plan for employees and apply other human resource development methods, as well as higher degree of decentralisation. In this subsection I will reproduce the analysis of intersectoral differences in organisational characteristics as measured by the composite indicators used by the FLEX-3 team.

The following histogram shows how the values of numerical flexibility indicator are distributed in the different sectors. While in manufacturing industries most of the firms have numerical flexibility around 1, the distribution for service sector is relatively more even and also skewed towards higher values of numerical flexibility.

Figure 5.5
Distribution of the rounded values of numerical flexibility indicator for different sectors, year 1998



On the following figure distribution of decentralisation degrees is shown. Firms in the service sector on have relatively higher degree of decentralisation, which is sensible, since, for example, service firms often comprise several workplaces and each of them may have more freedom in decision making.

Figure 5.6
Distribution of the values of decentralisation indicator for different sectors, year 1998

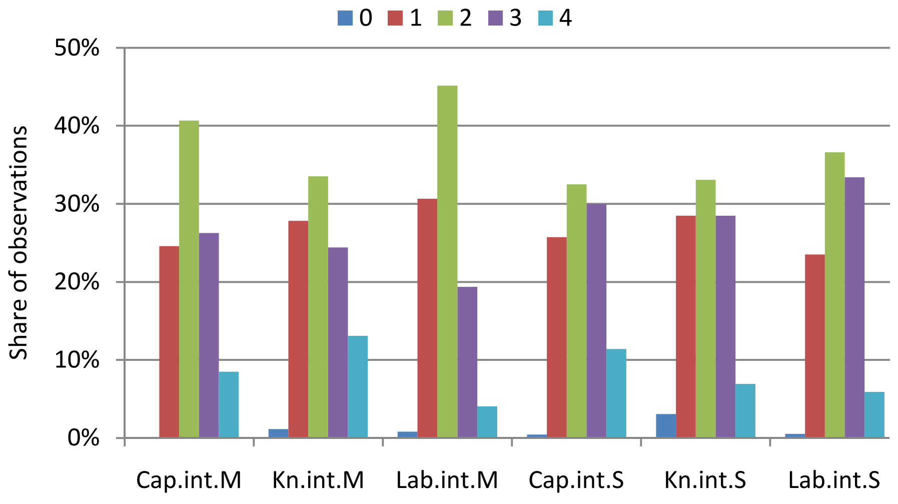
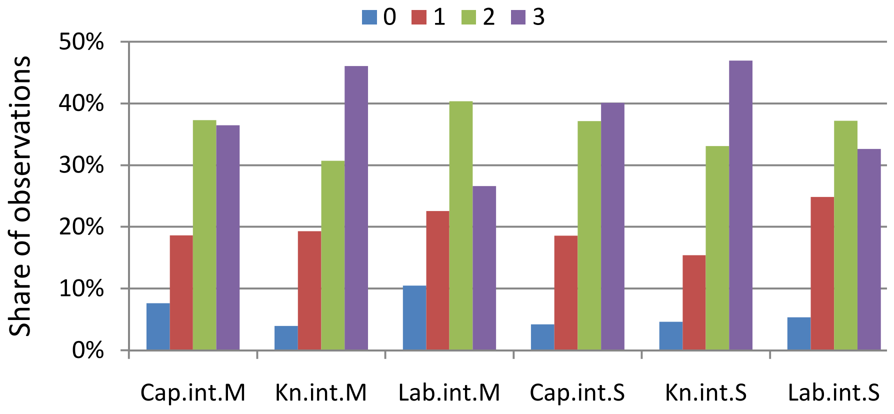


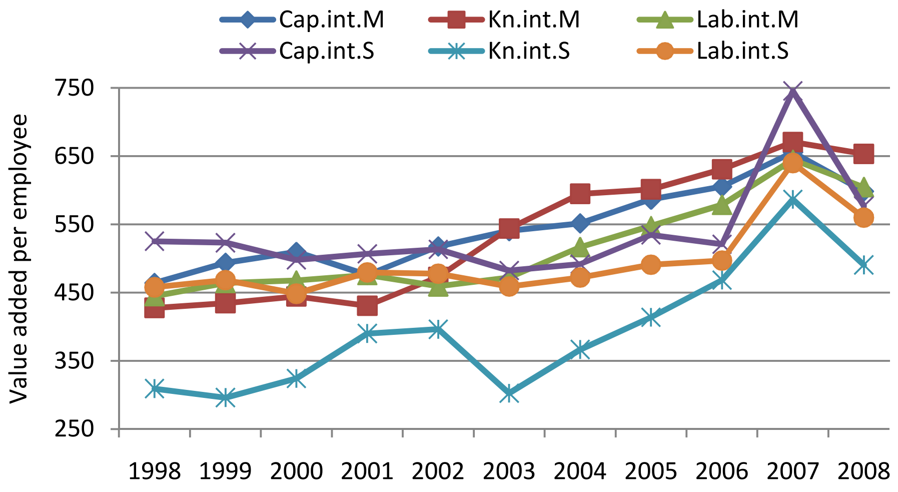
Figure 5.7 presents how the values of individual learning indicator are distributed across sectors and the pattern is predictable. Firms in knowledge intensive sectors tend to implement individual learning strategies relatively more actively. Labor intensive firms are characterized by least degree of individual learning. No substantial difference between manufacture and service is observed.

Figure 5.7
Distribution of the values of individual learning indicator for different sectors, year 1998



The differences in the distributions of the composite indicators indicate that there are more or less substantial variations in organisational characteristics across the sectors. Is it so that belonging to a certain sector/industry can explain differences in the levels of labor productivity? The following graph shows development of labor productivity over time, where each line corresponds to a certain sector. It can be seen that there is no clear pattern defining productivity from the sector, except for lower productivity in the knowledge intensive sector, which can be explained. As table 5.4 shows, knowledge intensive service sector includes among others educational, research and development and health institutions, which do not regard profit as main goal but rather serve as elements of infrastructure in the economy. These institutions tend to be publicly owned, have a specific structure of value added and therefore productivity.

Figure 5.8
Labor productivity by sector. Labor productivity measured as value added per employee, 1000 SEK, current prices



Remembering substantial and stable differences in the levels of productivity for different values of the composite indicators, it seems possible to conclude that productivity gaps can be attributed to organisational characteristics rather than being barely sectoral.

5.3 Econometric analysis

We have seen positive and persistent over time link between degree of decentralisation and individual learning and productivity and negative link between numerical flexibility and productivity. In order to evaluate these relationships regression analysis has been applied as described in the previous section.

Table 5.2 shows estimated coefficients of the composite indicators in equations with labor productivity as dependent variable. Other explanatory variables included are logarithm of capital per employee, dummies for size group, industry group or sector, dummies indicating flexible firms[101] and firms active in R&D[102].

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[101] Equal 1 if the firm carried out a change of continuous nature during 1995-1997, 0 otherwise.

[102] Equal 1 if the firm invested in service and product development more than 5 percent of its turnover in 1997.

Table 5.2
Regression results. Log labor productivity as dependent variable

Model	OLS		Random Effects GLS		Mixed Effects Restricted ML	
	17 ind	6 sec	17 ind	6 sec	17 ind	6 sec
Numerical Flexibility	-0.052***	-0.065***		-0.068*		-0.056*
Decentrali-sation	0.055***	0.054***	0.060***	0.059***	0.056***	0.052***
Individual Learning	0.031***	0.028***	0.059***	0.052***	0.067***	0.055***
Structural Learning	-0.031***	-0.020**				
Financial Flexibility	0.034***	0.034***	0.056**	0.051**	0.059**	0.050**
Flexible firm	0.043***	0.042***	0.060*	0.064**	0.062*	0.069**
Adjusted R-squared	0.9892	0.9890	n/a	n/a	n/a	n/a
R-sq:within			0.0414	0.0407		
between			0.1638	0.1191		
overall	n/a	n/a	0.1199	0.0991	n/a	n/a

Number of obs. N = 11986
Note: * significant at 10%, ** significant at 5%, *** significant at 1%

All the model specifications estimated suggest significant positive link between productivity and both decentralisation and individual learning. Particularly, firms implementing another component of decentralisation or individual learning are predicted to have 5 to 6 percent or 3 to 7 percent respectively higher labor productivity. Most specifications predict negative relationship between productivity and numerical flexibility. Applying payment criteria based on individual performance has positive link with productivity.

I have also analyzed the change in productivity using multifactor productivity development. Equations explaining multifactor productivity growth with the organisational characteristics do not let us make sound conclusions. Only capital variable and sector or industry dummies turn out to be statistically significant. We did not see any significant correlations between productivity growth rate and organisational indicators either. One possible explanation is the following. Graphs on the figures 5.1-5.4 do show differences in levels of productivity for firms with different values of organisational indicators, but general widening or narrowing of the gaps is not observed, therefore substantial differences in rates of productivity growth are not intuitively expected. Moreover, the measure of multifactor productivity growth is constructed of many variables including gross sale, value added, labor and capital input. As has been previously shown, a firm with higher degree of decentralisation is likely to have higher value added and gross production per employee (due to the strong correlation between them), but also higher labor costs (fig.A.1). So the positive effect of higher decentralisation might be eliminated by higher wage and social expenses, resulting in no observable effect on multifactor productivity.

The regression analysis confirms the expectations based on theory and previous research on relationship between organisational characteristics and productivity levels. On the contrary, no significant ling was found between work organisation and productivity growth rate.

5.4 Who survives?

When studying firms over longer periods of time one has to account for market dynamics, implying that the market is constantly changing with some firms disappearing and new firms coming. At the same time this dynamics gives a chance to study characteristics of the firms disappearing and surviving and thus make conclusions about possible determinants of a firm's survival.

There are 176 firms that did not make it to year 2008 in the dataset used. First, let us look at the distribution of these firms over industry groups and sectors and compare it to the whole sample distribution. Distribution of survivors and non-survivors over sectors and industry groups is presented in the Figures 5.9 and 5.10.

Figure 5.9
Distribution of survivors and non-survivors by sector

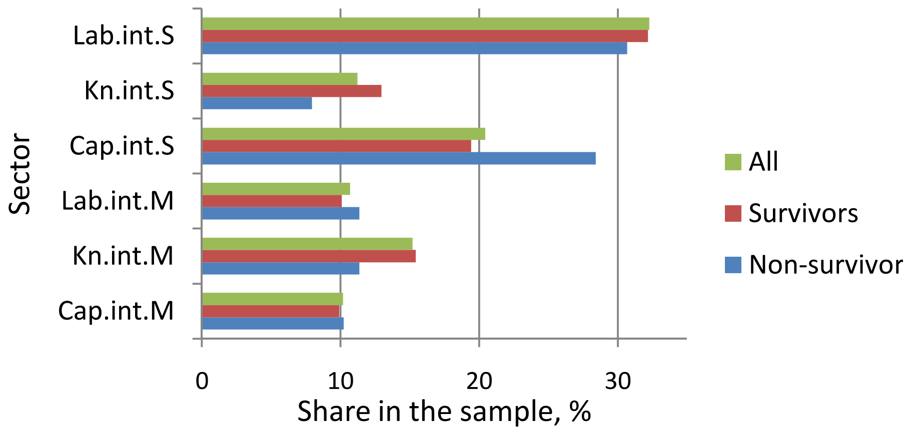
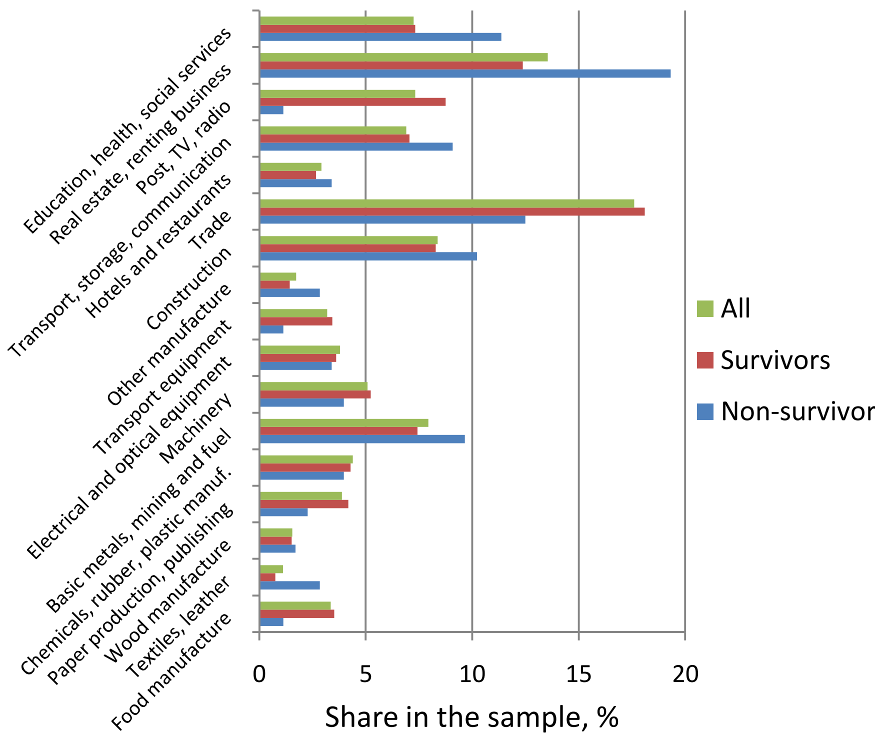


Figure 5.10
Distribution of survivors and non-survivors by industry group



Capital intensive service sector is remarkably overrepresented among non-survivors as compared to survivors and total sample, while firms from knowledge intensive manufacture and service sectors comprise lower share. In other words, based on the data we can observe that a firm operating in capital intensive service sector is less likely to survive, while a firm from knowledge intensive sector, both service and manufacturing, has greater chances to survive. Concerning industry groups, there are both over- and underrepresented groups among non-survivors. Following industries have higher share of non-survivors as compared to survivors and total sample: real estate and renting business, education, health and social services; basic metals, mining and fuel; textiles and leather manufacture; transport, storage and communication. The firms in the following industries are more likely to survive: post, TV and radio; trade; food manufacture; paper production and publishing. These industry groups surely correspond to the sectors described earlier since these are just two different classifications made to account for differences between branches as well as similarities within certain groups.

In the context of this paper we are interested to find out if organisation makes any difference in terms of firms' survival. In order to answer this question, we look if the values of the organisational indicators differ between survivors and non-survivors.

Table 5.3
Average values of the indicators for survivors and non-survivors

	Non-survivors	Survivors	Total
Numerical flex.	1,087	1,103	1,103
Decentralisation	2,074	2,197	2,192
Individual learning	1,886	2,093	2,082
Structural learning	1,254	1,345	1,332
Fin.flexibility	1,158	1,187	1,183

To verify and confirm this preliminary conclusion, I use a logit model to estimate the effect of organisational indicators on the chance of a firm to survive when industry and size are accounted for. In this case the dependent variable is the indicator for survival equal to 1 if the firm exists in 2008 and 0 if the firm does not exist. The results of the estimation are presented in the following table.

Table 5.4
Effect of work organisation on firm's survival. Logit estimation

Variable	Coefficient est.	Std. Err.	z	P>z
Decentralisation	0.167	0.097	1.72	0.086
Num.flexibility	-0.006	0.194	-0.03	0.974
Ind.learning	0.222	0.105	2.11	0.035
Str.learning	0.029	0.137	0.22	0.830
Fin.flexibility	0.029	0.235	0.13	0.900

Number of obs. N = 1164
Pseudo R2 = 0.0904

The survival of the firms is a very interesting subject which is broadly addressed to in the economic literature. Survival is the ultimate goal of a firm and probably the main indicator of its performance. Our analysis shows presence of at least some link between a firm's organisation and survival.

6 Conclusions and potential further research

The objective of this paper as part of the FLEX-3 project was to investigate work organisation and productivity from the long-term perspective.

For this purpose data from FLEX-2 survey was used to study organisation in the same terms as in the FLEX-3 project. Composite indicators were constructed to measure firm's flexibility and the relationship between these indicators and productivity was studied and evaluated. The regression analysis found that higher degree of decentralisation and active individual learning are positively related with labor productivity level. On the contrary, firms with higher numerical flexibility tend to have lower labor productivity and pay lower wages. However no significant effects of flexibility characteristics on productivity growth were found.

Higher degree of decentralisation and engagement in individual and structural learning practices prove to be positive for firms' survival. Numerical flexibility and individual payment system do not seem to matter for firm's survival.

Going back to the components from which the indicators were constructed, I can interpret the results in a more comprehensive way. Firms allowing for flexible working hours, letting their employees to plan their work and perform quality control and introducing performance-based payment schemes tend to have higher productivity. Other factors enhancing productivity are team work, presence of elements of skills development in everyday work, letting employees to participate in training or courses and creating individual human resource development plans for employees. Engaging in these practices raises the firm's chances to stay on the market in the long run. On the contrary, firms with many temporary employees or employees working part-time as well as hired from work agencies tend to be less productive.

I must highlight some of the limitations of the analysis performed in this paper. First, the answers to the survey questions may depend on who in the firm they were addressed to, since managers at different organisational levels often have different perception of the processes in the firm. This problem may be assessed by interviewing both employers and employees and then matching the results. This method is being applied in the survey in Denmark and will be used in future surveys in Sweden. Second, outsourcing and project based employment have become extremely popular, with many employees working in one firm but being officially employed by another, which creates difficulties in matching the employees with employers. Consulting and recruitment companies have to be treated according to specific of their work in this kind of survey, and there is an ambition to implement it in the future studies as well.

The possible and prospective developments of this research area are the following. First, a similar study can be implemented based on the data of the FLEX-3 survey, and the results compared with the conclusions of this paper. Second, with the extensive data on individuals available in Sweden, the relationship between a firm's organisation and career of its employees can be followed over shorter or longer periods of time. Third, future surveys can create a panel with a possibility to study organisational change. The extensive panel will allow studying causal relationship between organisation and performance. The link between a firm's organisation and its survival in the long-run can be addressed in a more thorough way.

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Appendix

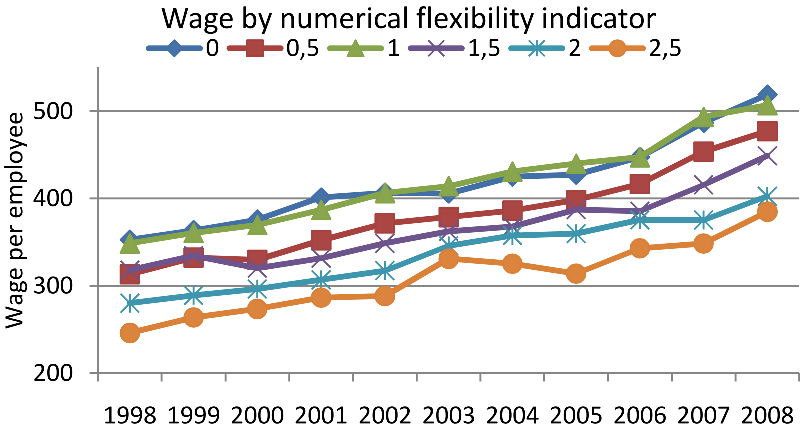
Table A.1
Questions from FLEX-2 in the construction of the composite indicators

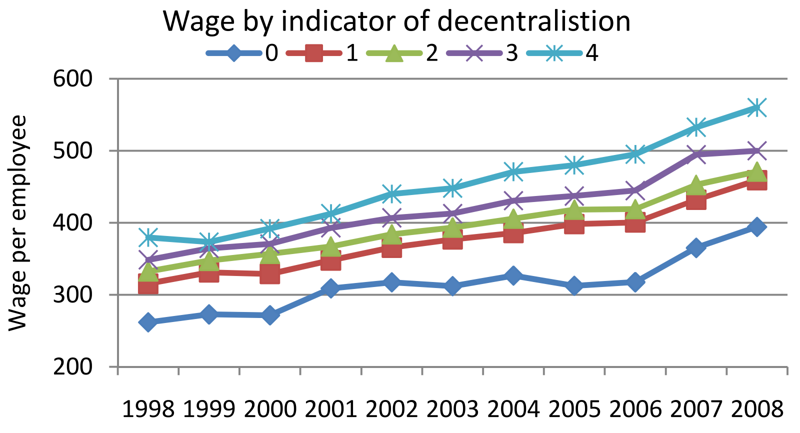
	Indicator / Questions	Values
	Numerical flexibility = NF1+NF2+NF3+NF4	[0, 2.79]
Q15*	Proportion of part time employees	NF1: [0, 1]
Q20	If you employed personnel on a temporary basis in 1997, what was the proportion of this type of personnel?	NF2: [0, 1]
Q25	If you used the services of other enterprises to pursue your core business in 1997, how large was this input compared to that of your own labor force?	NF3: [0, 1]
T22	Is the everyday/normal work in direct production organised so that the employee alternates between a number of different working tasks/operations?	NF4: 0 or 1
	Decentralisation = D1+D2+D3+D4	**[0, 4]**
Q21	What proportion of the personnel had the following forms of working hours in 1997? Fixed working hours: *A percent* Flexible working time between certain hours: *B percent* Free disposition of working hours: *C percent.* If you adjusted working hours to business cycles in 1997, what proportion of the personnel was involved? *D percent.*	D1: 0 or 1; 0 if *A* ≥ *90* 1 if *B* ≥ *20* or *C* ≥ *50*. 1 if *D* ≥ *50*
T17	Which of the personnel normally carry out the following tasks in direct production? Daily planning of one's own work Weekly planning of one's own work Quality control and follow-up of results a) individual employees b) work teams c) local manager/supervisor d) somebody else e) does not apply	D2: 0 or 1, 1 if a. D3: 0 or 1, 1 if a. D4a: 0 or 1 1 if answer to any is b
T13	Is the work organised so that people with different professional functions or positions carry out work together? In the production of services and goods In planning the work In follow-ups of the results and quality control In selection of production technology In service and product development a) yes, normally b) yes, in special cases c) no, not at all d) does not apply	D4b: 0 or 1 1 if answer to any is a D4=1 if D4a=1 or D4b=1
	Individual learning = IL1+IL2+IL3	**[0, 3]**
T20	Does the everyday/normal work in direct production contain elements of organised skills development?	IL1: 0 or 1, 1 if yes
T22	Is the everyday/normal work in direct production organised so that: the supervisor continuously makes higher demands in respect of existing working tasks; the employee himself further develops existing working tasks the employee himself develops new working tasks	IL2: 0 or 1, 1 if marked

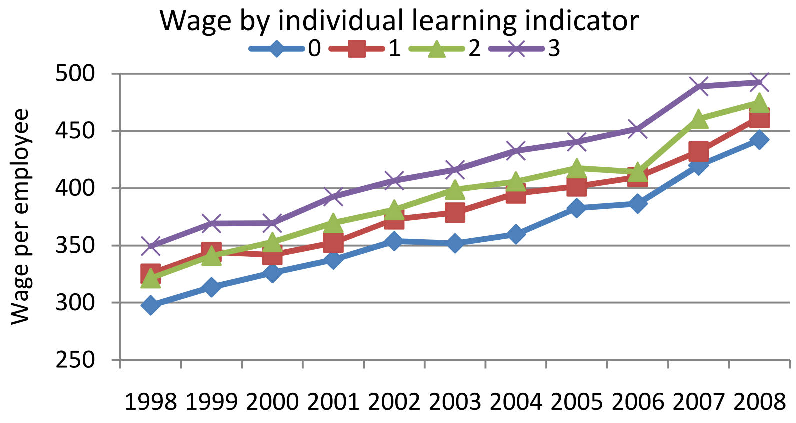
	Indicator / Questions	Values
T23	What proportion of the employees in direct production participated in training/courses which were wholly or partly paid for by the employer in 1997?	IL3: 0 or 1, 1 if ≥50%
	Structural learning = SL1+SL2	**[0, 2]**
T19	Does the workplace have a human resource development plan for every employee in direct production?	SL1: 0 or 1, 1 if yes
Q11	Where did you get the ideas for your minor and major innovations/changes? Customers, competitors, consultants principal source contributing source does not apply	SL2: 0 or 1, 1 if a or b
	Financial flexibility = FF	**[0, 2]**
T25	What proportion of the wages for the employees in direct production is based on different types of individual wage criteria?	0 if ≤ 20%, 1 if > 20% and ≤ 80%, 2 if > 80%

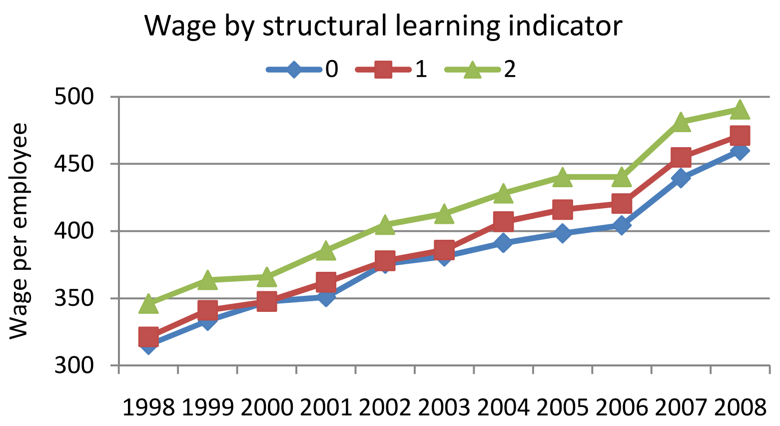
*T of Q before the question number denotes if the question is included in the telephone interview or the questionnaire sent by post, respectively.

Figure A.1
Wage and composite indicators









Note: Wage per employee is measured in 1000 SEK, current prices.

Table A.2 Composite indicators by industry group

Industry group	Num.flex.		Decentralisation		Ind.learning		Struct.learning	
	Mean	St.dev.	Mean	St.dev.	Mean	St.dev.	Mean	St.dev.
Food manufacture	1,16	0,35	1,97	0,88	1,95	0,84	1,41	0,70
Textiles, leather manufacture	1,07	0,35	1,95	0,61	1,98	0,76	1,23	0,81
Wood manufacture	1,11	0,21	2,04	0,90	1,67	0,76	1,09	0,70
Paper production, publishing	0,92	0,45	2,00	0,98	2,36	0,80	1,47	0,61
Chemicals, rubber, plastic manuf.	1,02	0,39	1,93	0,78	1,84	1,08	1,37	0,65
Basic metals, mining and fuel	1,06	0,39	2,13	0,90	1,93	0,93	1,45	0,61
Machinery	1,08	0,33	2,38	0,93	2,07	0,85	1,38	0,67
Electrical and optical equipment	1,16	0,28	2,04	1,09	2,48	0,74	1,47	0,59
Transport equipment	1,11	0,31	2,69	1,01	2,18	0,99	1,30	0,65
Other manufacture	1,14	0,22	1,88	0,84	2,10	0,95	1,36	0,64
Construction	1,11	0,37	2,25	0,97	1,99	0,84	1,23	0,64
Trade	1,12	0,51	2,20	0,88	2,02	0,91	1,25	0,74
Hotels and restaurants	1,42	0,64	2,31	0,77	1,93	0,93	1,15	0,67
Transport, storage, communication	0,98	0,49	1,77	0,85	1,85	0,92	1,22	0,68
Post, TV, radio	1,20	0,44	1,97	0,98	2,08	0,94	1,43	0,58
Real estate, renting business	1,09	0,46	2,55	0,94	2,32	0,74	1,55	0,60
Education, health and social services	1,15	0,53	2,35	0,90	2,27	0,72	1,17	0,71
Total	1,10	0,45	2,19	0,94	2,08	0,89	1,34	0,67

From Production to material Well-being: A national accounts measurement agenda for the OECD

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1. Introduction

The OECD, in common with many other organisations and economists, has typically measured material living standards in terms of the level and growth of gross domestic product (GDP). But for a number of years, there has been evidence of a growing gap between the image conveyed by GDP and the perceptions of ordinary people about their own conditions. While this gap was already evident during the years of strong growth and 'good' economic performance that characterised the early part of the decade, the financial and economic crisis of the past few years has further amplified it and strengthened the case for supplementing GDP by alternative measures that are better able to capture people's well-being.

The recognition that GDP is not a good measure of well-being is not new. One level of discussions can be subsumed under the heading 'money alone does not make you happy' and states that in addition to economic resource, there are other dimensions that shape the quality of life. These discussions go back at least to the social indicator movement in the 1970s. They have resurfaced over the past years. An international initiative on *Measuring Progress of Societies* that was launched by the OECD in 2004[104] is just one example of the re-appearance of this discussion. Another example is the report by

[103] Opinions expressed in this paper reflect the views of the author and not necessarily those of the OECD or its member countries.

[104] http://www.oecd.org/pages/0,3417,en_40033426_40033828_1_1_1_1_1,00.html

the *Commission for the Measurement of Economic Performance and Societal Progress*, also known as the *Stiglitz-Sen-Fitoussi Commission* (Stiglitz, Sen, Fitoussi 2009) put in place by President Sarkozy in 2008. Finally, there is an increasing number of new national publications on progress-related indicators (for instance, *Measures of Australia's Progress;* ABS 2010). All this speaks to the same issue, namely that material well-being only constitutes one, albeit important, dimension in the multi-faceted characteristics that determine people's quality of life. The present document will not dwell on the various dimensions of quality of life but take a look at *material* well-being or living standards and ask how GDP, income and productivity relate to this particular dimension of quality of life.

2. Current material well-being: GDP, productivity and household income

GDP is a measure of the value-added created through production that takes places within the "production boundary" of the System of National Accounts. Essentially, this comprises the production of goods and services destined at markets as well those goods and services provided for free by government and non-profit institutions. GDP and its main components are powerful and well-developed tools to monitor market activity as well as important parts of non-market economic activity. In economic models where production processes are represented through a production function that links outputs to inputs, output is typically measured as volume GDP whereas inputs are captured by measures of labour and capital. Thus, for purposes of representing the supply side of the economy, GDP appears as the appropriate tool. By the same token it is also useful to base multi-factor productivity measures[105] (MFP) on GDP as a measure of output and labour and capital as measures of inputs. MFP is the ratio between output and combined inputs and a rise (fall) in MFP indicates that more (less) output has been produced with the same volume of inputs. Typically, technical change and innovation are considered the driving forces behind MFP growth. While this observation is of no particular relevance to the following discussion on current material well-being, it will be relevant in the context of dynamic material well-being, of which more in section 3 below.

[105] See OECD (2001), Jorgenson (2005) or Diewert and Nakamura (20XX) for an overview of approaches towards productivity measurement.

While GDP is thus a useful variable to monitor production and the delivery of final products to the economy, it does not fare very well as a measure of the material well-being that people derive from it. There are three main reasons for this. The first is that some of the activities included in GDP correspond to a reduction in peoples' well-being (as in the case of higher transport costs due to higher congestion and longer commuting) or to activities aimed at remedying some of the social and the environmental costs associated to production (as in the case of environmental protection expenditures). The second reason is that some economic activities that undoubtedly contribute to people's material well-being such as household production of non-market services (child care, care of the elderly by their children, neighbourly help etc.) are not captured by GDP. The third reason is that the evolution of GDP does not correlate very well with the evolution of economic resources that are available to the typical household.

These deficiencies of GDP as a measure of well-being[106] suggest therefore that other measures are needed alongside GDP to capture material well-being and living standards. Indeed, a red thread through the Stiglitz-Sen-Fitoussi report is the search for measures that are 'close to people' – in other words measures that allow individuals to recognize their personal situation more easily than in broad-based measures of economic activity such as GDP. In the case of material living standards, the basic proposition is to:

- focus on measures of income rather than on measures of production;
- focus on households rather than on the entire economy,
- recognize that averages are not always representative,
- expand the conventional boundary of consumption (and income) to cover non-market production of household services,
- consider measures of wealth in addition to measures of income.

Each of these avenues is a way towards more granular measures of income and consumption possibilities for households and individuals. They have been taken up in the OECD's measurement agenda (Table 1) and we shall consider them in turn.

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[106] The international *System of National Accounts* (SNA) explicitly guards against the use of GDP as a measure of welfare (see for instance paragraphs 1.75-1.84 of the 2008 SNA).

From the economy's gross production to net adjusted disposable income of households

A first step towards better measuring material well-being is to focus on measures of income rather than on measures of production. This may seem odd at first because by construction, the value of domestic production equals domestic income earned in the production process. However, some of this income is paid to non-residents, while residents receive some income from production in other countries. Domestic income can thus be augmented by the income flows received and reduced by the income flows leaving the country to arrive at the concept of national income, which is more relevant for the material well-being of residents of a country[107].

When capital goods are used in production they depreciate, that is they lose value due to wear and tear and obsolescence. Depreciation constitutes a charge against gross income – not all of which can be consumed lest the capital stock will progressively be eroded[108]. Thus, net income[109] is preferred to gross income when it comes to measuring material well-being. In national accounts terminology, and for the economy as a whole, the reference indicator is net national income (NNI).

NNI relates to the economy as a whole and may evolve differently from net income of the household sector as the shares in NNI of households, the corporate sector and governments in total NNI may change over time. As soon as one gets to a sectoral picture, there is also a question about the treatment of income flows between sectors. Sector income can be measured before or after the flows between sectors occur. In the first case, each sector's share in primary income would measured, in the second case, each sector's share in disposable income would be measured. Primary income relates for

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[107] For the majority of OECD countries there is little difference between the levels of GDP and GNI. There are however exceptions, most notably Ireland and Luxembourg; differences are also likely to be significant for many developing and emerging countries characterised by a significant presence of multinational enterprises in their territory (whose profits are then transferred abroad) and of immigrants working abroad (who transfer part of their income to their country of origin in the form of remittances).

[108] To preserve the capital stock, new (gross) investment has to be at least as large as depreciation.

[109] For the rest of this document and in line with National Accounts terminology, 'net' will always be used in the sense of the value of a variable after deduction of the value of depreciation.

example to compensation of employees (the bulk of which accrues to the household sector) and profits (the bulk of which accrues to the corporations sector). Disposable income is a better approximation of the economic resources actually enjoyed by individuals and households: it measures the income from all sources available to households after they have paid taxes, and after receiving monetary social benefits. A further refinement consists of including those goods and services that households receive free of charge from the government and non-profit institutions, for instance health care, education and housing services. The resulting measure is adjusted disposable income[110].

[110] For an excellent discussion of various income measures for households and the economy as a whole in the United States see Landefeld et al. (2010).

Table 3.
OECD follow-up to the Commission on the Measurement of Economic Performance and Social Progress in the area of material well-being

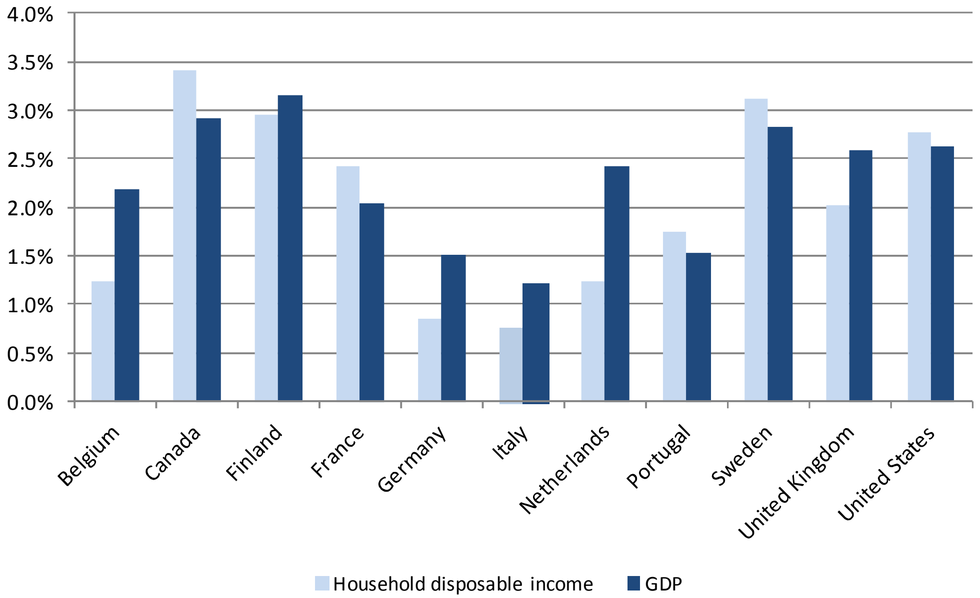
Recommendations *concerning the measurement of material well-being*	***The OECD …***
1. When evaluating material well-being, look at income and consumption rather than production	…is giving increasing prominence to indicators relating to net income for total economy and for household sector (for instance: *OECD National Accounts at a Glance*)
2. Emphasise the household perspective	…has started a quarterly collection of sectoral national accounts, including the household sector …is undertaking a study to de-composes the difference between the growth of GDP and real household income into its main components
3. Consider income and consumption jointly with wealth	…has launched work to develop a methodological framework for surveys to collect data on household income, consumption and wealth ...has, together with several countries, produced a first set of measures of human capital
4. Give more prominence to the distribution of income, consumption and wealth	…has set up an international task force to develop distributional information for the household sector in the national accounts (by income quintiles in the first instance)
5. Broaden income measures to non-market activities and improve the measurement of non-market services	…has produced a first set of estimates for the value of own-account production of household services ...has issued a handbook on the measurement of health and education output (OECD 2010) and undertaken international price comparisons of hospital services (Koechlin et al; 2010)

Figure 1 shows that household disposable incomes have risen less quickly than GDP in several countries in the past decade. One reason may be that profits rose quicker than compensation of employees, leading to a decreasing part of primary income that households can claim. Or the distribution of income through taxes, social benefits or the distribution of profits may have changed to the disadvantage of households. Another reason could be that there is a change in the prices of consumer goods relative to the overall price level of the economy[111]. It will be interesting to assess the relative importance of these components for the OECD countries and the OECD has launched a project to that effect.

An alternative to gauging material well-being via household income measures is via household consumption measures. While disposable income can be broadly described as an indicator of consumption and savings possibilities, final consumption expenditure of households takes the savings decision as given and looks directly at the goods and services acquired by households. When the in-kind services that households receive from government are taken into account as part of income and consumption, the measure of actual consumption applies as the parallel measure to adjusted disposable income. Consumption-based measures will be used below in the context of non-market production of household services.

[111] Note that a value of (disposable) income is not composed of a price and a volume component. Consequently, there is no price index that would break an income flow into an underlying price and quantity components. However, a price index can be used to express a nominal income flow in *equivalents* of certain goods or services. When measuring living standards, the preferred equivalence is consumer goods so the appropriate deflator in moving from nominal to real income is a consumer price index or a deflator of private consumption. This is not only intuitively appealing it is also strongly backed by economic theory (Sefton and Weale 2006). As the price of consumer goods tends to move differently from the overall price level in the economy, such a change in the 'consumer terms-of-trade' can raise or reduce real income relative to volume GDP.

Figure 10.
Volume GDP and real household disposable income
Average annual growth over the period 1998-2008



Source: OECD National Accounts.

Accounting for non-market production of services by private households

Estimates of production, income and consumption in the System of National Accounts are generally based on the idea that households are final consumers, rather than producers, of goods and services. Goods and services produced by households for the market are included in economic aggregates, as are goods produced for own-consumption, such as agricultural products and own-account construction, but non-market services produced by households for own-consumption, with the notable exception of dwelling services, are not included in economic aggregates in the SNA. There is little contention that many of the services produced by households for their own-use, such as cleaning services, preparation of meals, child-care etc contribute to material well-being and, moreover, that they share the characteristics of the same activities conducted by the market, which are included in the production boundary of the SNA. But they have always been excluded from the SNA production boundary.

Recently, work[112] has been undertaken in the OECD Statistics Directorate to estimate the value of own-account production of services by households in response to the increasing recognition and demands from policy makers for more comprehensive measures of material well-being. The non-market production of household services gives rise to consumption and to implicit income that the household 'pays to itself'. As there is no monetary transaction it is more difficult to communicate measures of non-market production on the basis of an augmented measure of income as opposed to an augmented measure of consumption. Hence, results are presented using consumption rather than income.

The work is still in its early stages, and focus on estimates of household production of non-market services for one year only, 2008. However, two messages already arise from these preliminary estimates.

Firstly, the value of own-account services of households is significant – depending on the country and the methodology chosen[113], it varies between 20 and 50 percent of traditionally-measured GDP. Secondly, allowing own-account services of households to enter the volume measure of consumption per capita changes the position of countries in international comparisons. Figure 2 below compares countries' per capita consumption relative to the United States according to three methods. The first, 'offical' calculation reflects actual individual consumption as presently measured in the national accounts. The second and third calculations refer to measures of total consumption where household production of non-market services has been added to actual individual consumption. 'Replacement costs' and 'Opportunity costs' refer to two methods of valuation of the labour used in household production. It is remarkable that in all countries, positions relative to the United States improve when household production is fully captured. This effect is largest at the lower end of

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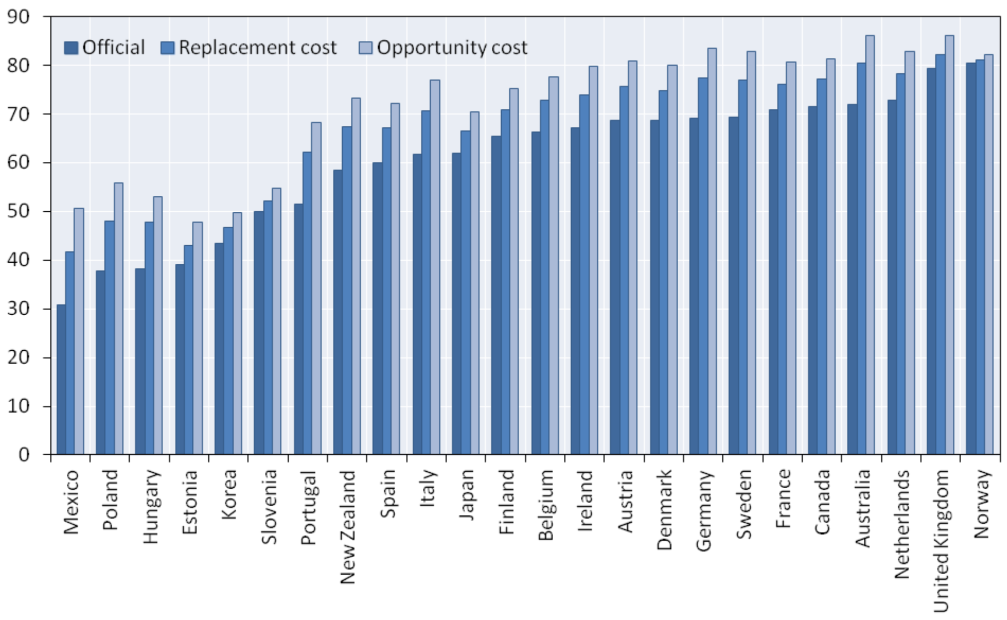
[112] For more detailed information on the methodology and data sources, see the forthcoming (2010) Statistics Directorate Working Paper: *Incorporating Household Production into International Comparisons of Material Well-Being*.

[113] Two approaches were examined to value the labour input (i.e., the time spent) in household production: the replacement cost approach and the opportunity cost approach. The replacement cost approach values time spent on household work with the wage of a household worker, the opportunity cost approach uses the average wage on the labour market. To labour input is added the value of capital services derived from durable consumer goods.

the consumption scale, for instance for Mexico or Poland. This is not entirely unexpected as lower income countries tend to have a less developed market services sector than higher income countries. Differences between countries may also reflect involuntary choices for example when unemployment obliges labour force participants to 'produce at home' while, unconstrained, they would have chosen to be salaried employees.

Figure 11.
Total household consumption: US dollars, 2008 PPPs, US=100



Source: OECD (2010 forthcoming).

Distributional aspects

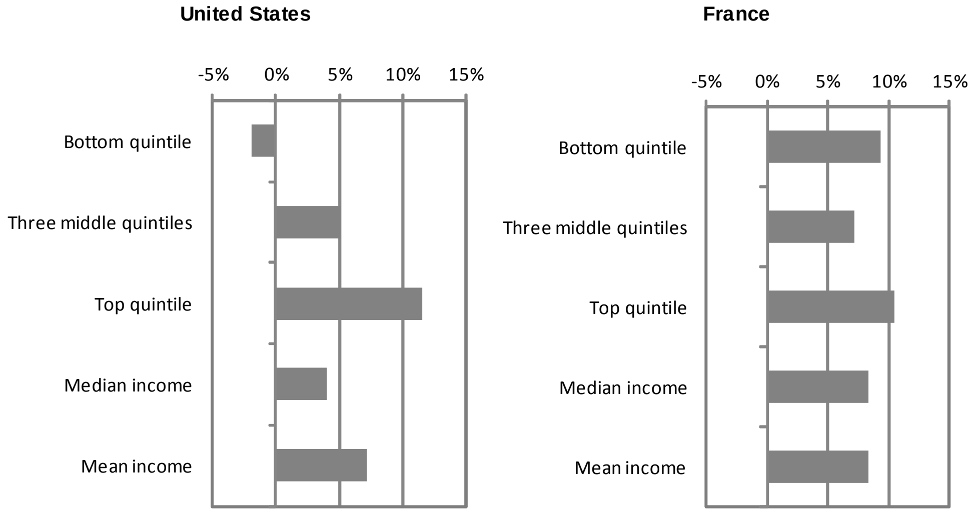
Mention was made earlier of a gap between peoples' perceptions on their material well-being and what average GDP per capita data showed. One possible explanation is that changes in average income are accompanied by changes in the distribution of income. For instance, when the distribution of income becomes more unequal, an increasing number of households may be worse off despite a rise in average income. While there is thus a conceivable link between income distribution and the gap between perceived and measured average income, it is not possible to say a priori what impact income inequality has on well-being. If it is assumed that extra income brings smaller and smaller increments in well-being to individuals and that all individuals with the same income experience the same well-being, then general well-being will be highest if all individuals have the same income; a corollary would be that any increase in income inequality with no changes in average income reduces well-being. But it can also be argued that the possibility of increasing one's income is needed to spur effort and innovation, which benefits society as a whole, and that individuals differ in their preferences for leisure as opposed to material goods.

Whatever these judgements, it is possible to adjust measures of household income per capita to incorporate distributional concerns. One such adjustment involves weighting average incomes in each decile of the distribution with a coefficient representing the degree of aversion to inequality of each society; a higher value of this coefficient implies that a lower weight is given to higher incomes (Kolm, 1969). Unsurprisingly, a high value for this coefficient can lead to a change in country rankings and affect country growth rates (Boarini et al., 2006).

Another, conceptually simple way of capturing distribution aspects is to look at median (alongside mean) income (Figure 3). The "median individual" is, in some sense, the "typical" individual, the one who stays exactly in the middle of the distribution. If inequality increases, the difference between medians and means will widen, and the mean will give a biased assessment of the way living conditions evolve. Data on median incomes and their evolution over time exist, along with other indicators on the distribution of households' income and wealth, but virtually all such information reflect the definitions of income and wealth from the underlying household surveys and these are typically different from the definitions in the national accounts, making it difficult to align the micro- and macro-economic picture[114].

[114] Deaton (2005) examines poverty measures from household surveys and national accounts and concludes: "A major problem is that consumption measured from household surveys, which is used to measure poverty, grows less rapidly than consumption measured in national accounts, in the world as a whole and in large countries, particularly India, China, and the United States. In consequence, measured poverty has fallen less rapidly than appears warranted by measured growth in poor countries. One plausible cause is that richer households are less likely to participate in surveys. But growth in the national accounts is also upward biased, and consumption in the national accounts contains large and rapidly growing items that are not consumed by the poor and not included in surveys. So it

Figure 12.
Growth in household disposable income* in the United States and France
Survey-based, cumulative growth over the period 1995-2005



*Note that 'disposable income' reflects the definition as in countries' household surveys and thus has a different contents from 'disposable income' in the national accounts. Further, disposable income is measured as equivalised income to account for different household sizes: every additional person in a household gets a smaller weight in the computation.
Source: Data drawn from OECD (2008), *Growing Unequal? Income Distribution and Poverty in OECD countries*, OECD, Paris.

France has been one of the first countries to undertake a study that combines distributional information from household surveys with sector-wide information from the national accounts to add consistent distributional information to the national accounts data on income of the household sector (Fesseau and Le Laidier 2010). Table 2 present a set of results from this work. It shows, for instance, the redistributive effects of social transfers in kind such as government-provided health and education services. Before accounting for these services, the income of the richest 20% of the population is just over 8 times that of the poorest 20%. With social transfers taken into account, the ratio falls to 3.2 for actual individual consumption. The OECD has initiated and coordinates similar research with other countries where data is available with a

is possible for consumption of the poor to grow less rapidly than national consumption, without any increase in measured inequality." (p. 1) view to producing internationally comparable comparisons of inequalities in household incomes in line with the national accounts.

Table 4.
Adjusted disposable income and actual consumption by income level (quintiles) France, 2003

per CU, in euro

	Q1	Q2	Q3	Q4	Q5	Q5/Q1	All households
Primary income	7 500	17 200	24 400	32 800	60 600	8,1	28 600
Contributions and taxes	-2 800	-6 600	-9 800	-13 500	-24 800		-11 500
Benefits and other transfers	5 400	5 800	6 400	7 500	14 200		7 800
Disposable income	10 100	16 400	21 000	26 800	50 000	5,0	24 900
Social transfers in kind	**7 400**	**5 900**	**5 400**	**5 000**	**5 100**	**0,7**	**5 800**
Adjusted disposable income (after social transfers in kind)	**17 500**	**22 300**	**26 400**	**31 800**	**55 100**	**3,2**	**30 700**
Consumption expenditure	9 900	15 400	19 800	24 400	33 100	3,3	20 600
Actual consumption	**17 300**	**21 400**	**25 100**	**29 400**	**38 200**	**2,2**	**26 400**
Social transfers in kind in % of disposable income	*73*	*36*	*26*	*19*	*10*		*23*
Social transfers in kind in % of actual consumption	*43*	*28*	*22*	*17*	*13*		*22*

Covers the population living in ordinary households, mainland France. FISIM is excluded.
Source: Fesseau and Le Laidier (2010).

3. Dynamic material well-being

Concepts

Having dealt with the choice of income measures that are most relevant in our quest for a per-period or static expression of material well-being, we shall now turn to a more dynamic consideration. In a paper that spawned a whole branch of 'green accounting' literature, Weitzman (1976) demonstrated how in a simple, closed economy, a measure of real net national income takes meaning as a dynamic (material) welfare measure. He showed that under certain assumptions real net national income115 is proportional to the present discounted value of consumption that the economy is able to produce.

[115] Weitzman (1976) and the ensuing literature refers to net national *product* rather than net national *income*. For reasons mentioned above, we have a preference for couching the discussion in terms of income. See Hulten and Schreyer (2010) for further discussion.

There is a direct link to Hicks' (1939) well-known definition of income. In its most general form Hicks describes income as "...the maximum value which [a person] can consume during a week, and still expect to be as well off at the end of the week as he was at the beginning". Sefton and Weale (2006) showed how Weitzman's insights can be generalised and turned into a rigorous formulation of Hicks' definition. In particular, they demonstrated that, in a market economy, real net national income corresponds to the maximum possible consumption that can be realised during a period without reducing society's intertemporal utility. They also showed that for this interpretation to hold, real net national income and its components should be expressed in equivalent bundles of consumption goods which amounts to deflating nominal national income by a consumption deflator. It is helpful to spell this result out more formally. In what follows, let NNDI(t) be real net national disposable income deflated by a consumption price deflator at time t, let C(t) stand for final consumption by households and government, and let S(t) be net savings in the economy. Denote with dV(t) the change in intertemporal utility, expressed in consumption units. Sefton and Weale's (2006) showed that Hicksian income, HI(t) can be expressed as

$$HI(t) = NNDI(t) = C(t) + dV(t) \qquad (1)$$

From (1), it is apparent that when intertemporal utility is unchanged (dV(t)=0), maximum consumption, call it C*(t), equals NNDI(t). Expression (1) also helps to interpret net national disposable income as the sum of two effects: current consumption C(t) and additions to (or subtractions from) future utility. Indeed, much of the discussion in section 2 of the present paper has been about current material well-being and therefore about variants of expressing C(t). The dynamic considerations in the current section add the inter-temporal effect dV(t) to this discussion by focusing on net national disposable income. Another remark concerning expression (1) arises from the observation that NNDI also equals final consumption plus net savings: NNDI(t) = C(t)+S(t). It is not difficult to see that S(t) = dV(t) and that savings consistent with maximum possible consumption C*(t) is S(t)=0, i.e., zero real net saving. Positive real net saving will enhance future consumption possibilities, whereas negative real net savings will reduce them and so indicate non-sustainable consumption. This is also the idea behind the World

Bank's Genuine Savings Measure that has been used as an indicator of (non)sustainability[116].

One important omission in Weitzman's (1976) initial analysis was the absence of autonomous productivity change, i.e., shifts in the production possibility frontier that are simply time dependent and largely reflective of one of the major drivers of economic growth, innovation. This is a potentially important omission, because costless advances in technical efficiency are welfare-enhancing, and may mitigate the problem of exhaustible resources (along with product-oriented technological advances). Nordhaus (1995) was among the first to demonstrate that net income by itself is not a sufficient indicator of future consumption possibilities, and that it needs to be augmented by the effects of disembodied technical change[117].

Nordhaus computes a new series of real net national income adjusted for productivity change for the United States and finds a sizeable discrepancy between the measures adjusted and unadjusted for future productivity growth. Similar results were established by Weitzman (1997) and Weitzman and Löfgren (1997). Hulten and Schreyer (2010) identified another effect that needs to be taken into account in an open economy, changes in the price of domestic exports relative to the price of imports, i.e., the terms of trade. For an economy, an improvement in the terms of trade has very much the same effect as a rise in productivity – it provides 'free' purchasing power to the domestic economy. Both the effects of productivity change and terms of trade change can be factored into the computation of Hicksian income as explained above. This gives rise to an augmented version of Hicksian income HI'(t):

$$HI'(t) = NNI(t) + Z(t) - T(t) = C(t) + dV(t) \qquad (2)$$

[116] The World Bank Genuine savings computations are defined around a broader set of assets than in the System of National Accounts. Genuine savings aim to represent "…the value of the net change in the whole range of assets that are important for development: produced assets, natural resources, environmental quality, human resources, and foreign assets". See Hamilton and Clemens (1999) and http://search.worldbank.org/research?qterm=genuine+savings&_teratopic_exact=Environment .

[117] Subsequently, Weitzman (1997) made the same point and stated that "the proper measure of annuity-equivalent future consumption possibilities *with* the "Solow residual" might conceivably call for a sizable upward adjustment of Green NNP." (Weitzman 1997, p.2).

In (2), Z(t) is the income effect due to future productivity change and T(t) is the income effect due to future changes in the terms of trade. The reasoning above can now be applied again to identify maximum consumption during period t that leaves intertemporal utility unchanged (dV(t)=0) and one obtains C**(t) = NNI(t)+Z(t)-T(t).

C**(t) can subsequently be compared with the actual path of the economy's consumption, C(t), to yield an indication of sustainability of material well-being: C(t) > C**(t) would be a sign of unsustainable consumption and vice versa. However, before applying this rule and showing some empirical findings, several observations are in place:

- As part of the inter-temporal nature of Hicksian income, **investment** and **capital** enter the picture. Above, static measures of material well-being were formulated in terms of household income or consumption. Over time, however, additions to capital (gross investment) and subtractions from it (depreciation) need to be considered as there will be dynamic effects on household income even if capital goods are not directly owned by households. Investment is needed to maintain or raise the stock of capital available for production and so maintain or increase potential output of the economy. All this raises future consumption possibilities[118].
- Produced capital (that is capital built up through investment, for example machinery and euqiment) is reasonably well measured and part of the asset boundary of the System of National Accounts. But there are other assets that are either badly measured or outside the national accounts' boundaries. This does not mean they are irrelevant and from a conceptual perspective, Hicksian income may well relate to a much broader scope of assets than presently recognised in official national accounting conventions. Important omissions are **human capital** and **natural or environmental assets**. The OECD has started work on human capital estimates and will soon be able to relate them to the conventional set of assets. Natural and environmental assets are

[118] The discussion of Hicksian income was framed in terms of savings rather than investment but the link is direct. In a closed economy, all investment must be financed through savings. In an open economy, investment can also be financed through capital transfers from abroad or, more important in practice through borrowing from abroad. Suppose that all investment is financed through borrowing from abroad. While the financing arrangements will have no effect on our measure HI'(t) in the year of investment (and borrowing), they will reduce HI'(t) in subsequent years because interest payments to foreign lenders will reduce NNI.

centre stage in the discussions about green growth, more of which below.

- Final consumption C(t) in expressions (1) and (2) has been confined within the boundaries of the national accounts. However, the alternative estimates of '**total consumption**' that incorporate households' own production of services (section 2 above) are directly relevant in this context. The extended measure of consumption would enter C(t) and the corresponding income would enter NNDI(t). For practical reasons, however, the calculations of HI(t) to follow have been confined to the traditional boundaries of consumption measures at this moement[119]. Their inclusion is a matter of future research.
- There is a direct connection between HI and the notion of **green growth**, another project that looms high on the OECD agenda. Green growth is about economic growth that minimises the negative impacts on environmental assets. And green growth is also about harnessing opportunities for growth that arise from environmental protection. The conceptual link between HI and green growth arises when net investment relates to an asset boundary that includes natural assets. For example, depletion (extraction minus natural growth) of natural resources would reduce NNDI if the scope of assets is cast to include environmental assets. There are multiple practical reasons why it is difficult to compute a 'green NNDI'. In particular, the valuation of changes to the quality of environmental assets is fraught with difficulties. But the concept remains relevant. Expression (1) also shows that a discussion about green growth cannot ignore the discounted effects of productivity growth as captured by Z(t). Finally, it is apparent that welfare-related measures such as HI are formulated in terms of income, not production. This provides an indication what 'growth' should relate to in a quest for green growth. The target concept for material well-being is growth of Hicksian income (possibly

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[119] Integration of own-account production of household services in the calculations of HI(t) would reauire a time series of the own-account production. At present, no such time series data are available. Further, reasoning in terms of total consumption and income would require a consistent set of expanded household accounts, and there is some way to go before this is accomplished in a comparable way. In the following computation of HI, therefore, consumption and income will be kept within their traditional SNA boundaries.

adjusted for inequalities), not GDP so discussions about green growth are best couched in former rather than the latter.

Results

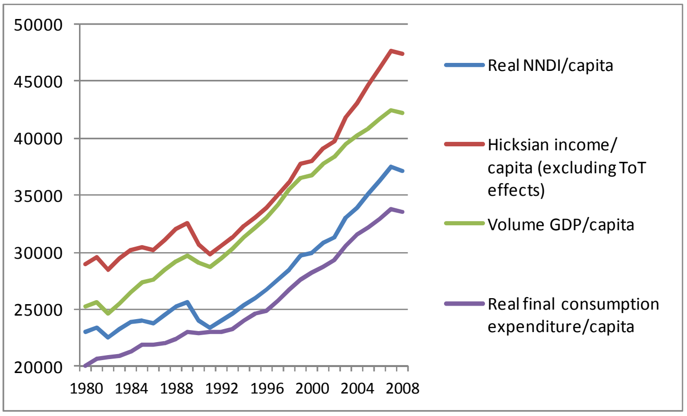
It is now time to move to some illustrative computations of Hicksian income HI′(t) as specified above. We present estimates for the United States, Australia and Sweden. No attempt is made to expand the asset boundary beyond what is recognised in the System of National Accounts. Also, we ignore the effect of future changes in the terms-of-trade on the grounds that it is unlikely for terms of trade to improve or worsen indefinitely. Results are illustrative only and should be interpreted with the necessary caution. But they turn out to be of interest all the same. Four time series are presented below: volume GDP per capita, net national income per capita in real terms (deflated by a consumption price index) and Hicksian income C**(t), that is NNDI(t) augmented by the term Z(t) that captures the effects of long-term productivity growth. Data for volume GDP and real NNI are taken directly from the national accounts, Z(t) has been computed based on the average rate of each country's multi-factor productivity growth over the period 1985-2007 as measured by the OECD[120]. In the case of Australia, the MFP rate was 0.9% per year, in the case of Sweden, the rate was 1.2% per year and in the case of the United States 1.1% per year.

It is worth noting here that these MFP rates are based on standard productivity computations where the growth rate of an index of combined labour and capital inputs is subtracted from the growth rate of volume GDP. Hulten and Schreyer (2010) have shown that although income needs to be measured net of depreciation in a calculation of HI(t), the productivity parameter entering the calculation can remain on a gross basis. The underlying idea is that productivity growth is a phenomenon that happens on the

[120] In Hulten and Schreyer (2010), Z(t) emerges as $Z \equiv \int_t^\infty (\lambda(s)G(s)/P_C(s))e^{-\int_t^s r^* d\tau} ds$ where is the expected rate of multi-factor productivity growth, G(s)/P(s) is future GDP deflated by a consumption price index and thus scaled in equivalents of consumption goods and services. Under the simplifying assumptions that the expected rate of is constant, that the expected rate of real GDP growth is zero, and assuming a constant 4% real interest rate r*, one obtains $Z \equiv \lambda G(t)/P_C(t)\int_t^\infty e^{-\int_t^s r^* d\tau} ds = \lambda G(t)/P_C(t)/r^*$.

production side of the economy and raises gross output over gross input[121].

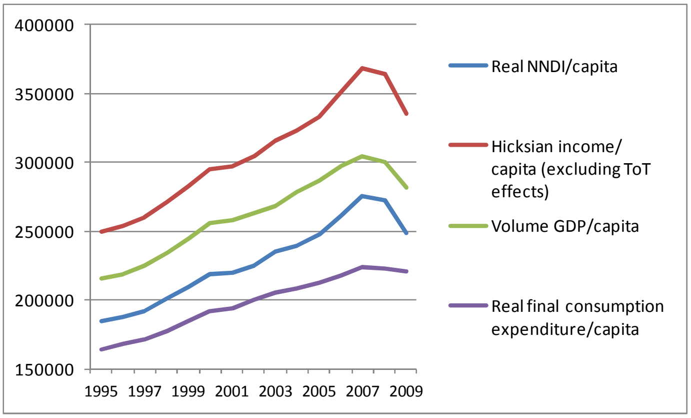
Figure 13.
Australia: real income and consumption measures and volume GDP per capita,
1000s of chained 2000 Australian Dollars per capita



Source: OECD Annual National Accounts and author's calculations.

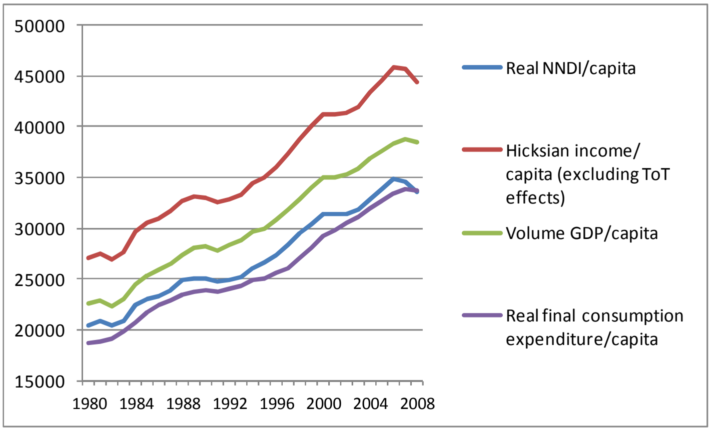
[121] Some authors (Diewert, Mizobuchi, Nomura 2009 and Diewert and Lawrence 2006) have chosen a net approach for productivity measurement although not necessarily in the context of computing a dynamic measure such as HI(t) but as an alternative approach towards measuring current productivity growth. Output then, is measured as the volume of net national product, and on the input side appear labour input and capital input, corrected for depreciation (Diewert 2006, 2010). The resulting time profile of productivity growth and its contribution to output tends to be different from the time profile of GDP-based productivity growth. In principle it should also be possible to introduce such a net productivity figure into a dynamic model to compute HI′(t) although it is not clear whether results would be identical. There are some more subtle issues in conjunction with the nature of depreciation and the possibility to split it up into a price and a volume component – for a discussion see Diewert (2010) and Hulten and Schreyer (2010).

Figure 14.
Sweden: real income and consumption measures and volume GDP per capita,
1000s of chained 2000 Swedish Krona per capita



Source: OECD Annual National Accounts and author's calculations.

Figure 15.
United States: real income and consumption measures and volume GDP per capita,
1000s of chained 2000 US Dollars



Source: OECD Annual National Accounts and author's calculations.

As would be expected (almost by definition), levels of real net national income are lower than volume GDP in all three countries. Growth rates over the period under consideration are similar although, as of the mid-1990s, in Australia and in Sweden, real national income grew faster than volume GDP. But the main message that emerges from this picture is the importance of productivity for the assessment of today's income levels. The Z(t) values presented here are lower bounds and yet, they show up with significant values, adding between 25 and 35% to net national income. This estimate is in the same ballpark as Nordhaus' (1995), Weitzman (1997) and Weitzman and Löfgren (1997). The latter show a figure of 41% and conclude:

> "No one should feel fully at ease projecting the kind of crude numbers that lie behind the raw calculation of u=41% onto the future, and, of course, u will change with different assumed values of the underlying parameters. Caution is therefore warranted when interpreting this kind of exercise at making a ballpark estimate of a 'sustainability index', however such a measure may be defined. Yet, a reasonable parametric analysis […] based, admittedly, on present data reflecting present historical conditions would appear to make the following conclusion difficult to contest: Because it omits the role of technological progress, NNP, whether conventionally measured or green-inclusive, seems to understate an economy's sustainability, which, at least as of now, probably depends more critically on future projections of technical change than on the typical corrections undertaken in the name of green accounting." (p. 149).

4. In conclusion

This document has ranged over several conceptual issues related to the OECD's measurement agenda in the area of productivity, income and material well-being. The following points emerge.

- GDP needs to be supplemented but not supplanted. Depending on whether the analytical interest lies with an analysis of the production side of the economy or with an analysis of material well-being, GDP will or will not be the right indicator.
- To monitor current material well-being, income related measures with a household perspective are called for and the OECD has started several projects in this area: measurement of non-market production of households, examining the factors that shape the

growth of real household income, investigating into how household income is distributed between households.

- Innovation and multi-factor productivity are the keys to see where measures of production and measures of material well-being come together. Both productivity and net income are needed in dynamic welfare measurement. Hicksian income (or in its inclusive form, sustainable income) needs to reflect the discounted effects of productivity change. Even by cautious standards, these effects are sizeable as our computations for three OECD countries have shown. Neglecting them would inject a serious bias into our assessment of material well-being and sustainable living standards.
- The inter-temporal measures of Hicksian income are directly relevant to reflexions on green growth. Green growth can be framed in a similar set-up but would require a broader set of assets including in particular environmental assets. This raises many measurement questions but should not distract from the conceptual usefulness of Hicksian income for definitions of ‘growth’ in the green growth concept and for the role of productivity in judging the possibilities of green growth.

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