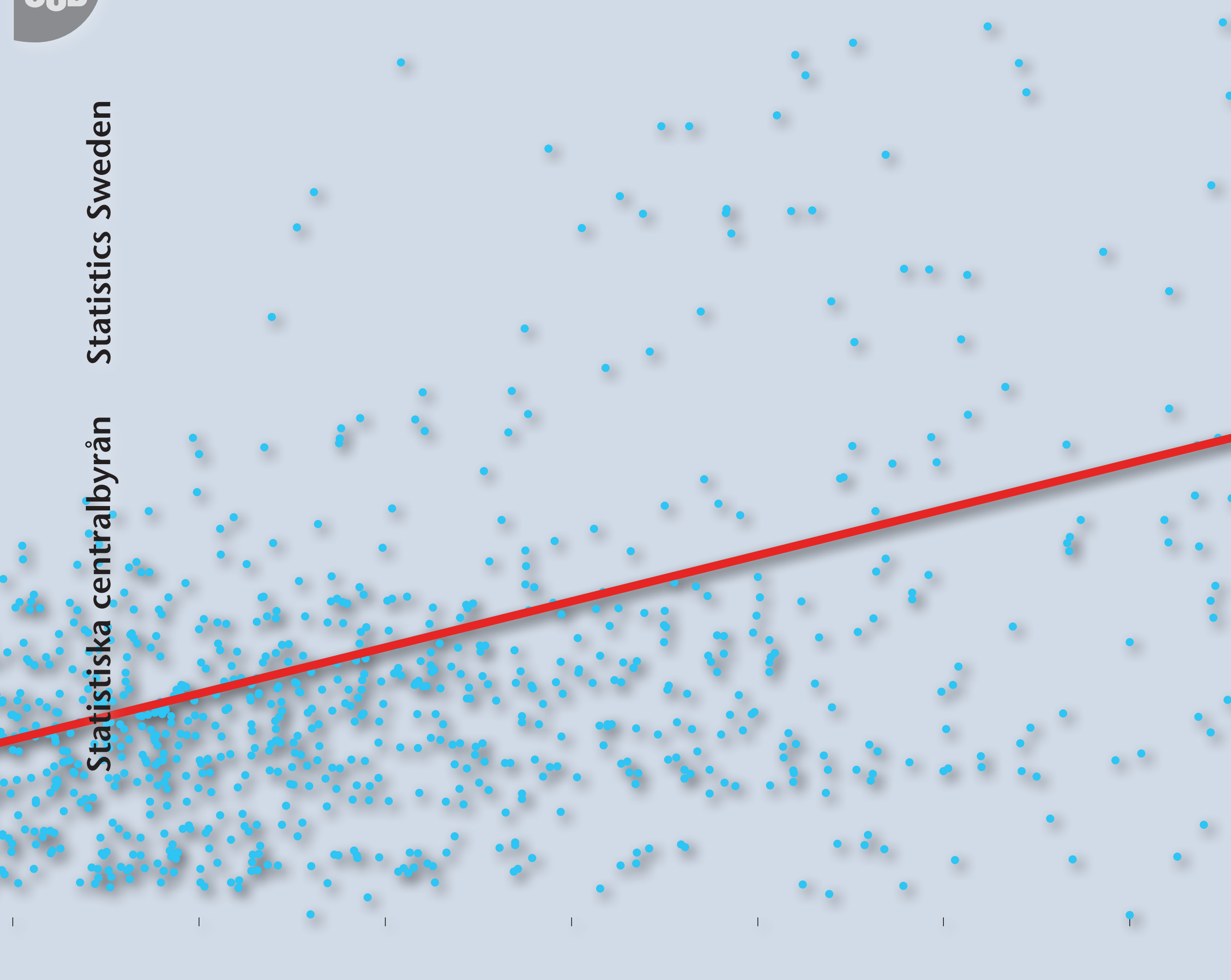
PAPERS PRESENTED AT THE
SALTSJÖBADEN CONFERENCE OCTOBER 2008



Statistiska centralbyrån Statistics Sweden

Yearbook on Productivity 2008

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Statistics Sweden
2008

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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.

This yearbook contains a number of productivity studies; some are more oriented towards measurement and some more towards analysis. 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 forth one and was presented at our yearly conference in Saltsjöbaden as the coming yearbook.

We want to especially thank George van Leeuwen Statistics Netherlands and Shikeb Farooqui Office for National Statistics UK, Mark Franklin, Peter Stam and Tony Clayton Office for National Statistics UK, Andrew Wyckoff Deputy Director for DSTI at the OECD and Jennie Glantz and Malin Nilsson at the University of Stockholm for their contributions. Those involved in this yearbook at Statistics Sweden include; Clara Ferdman, Ingrid Persson, Katarina Johansson and Gunilla Nockhammar, Daniel Lennartsson, Annika Lindblom and Fredrik Nilsson, Ann-Marie Bråthén, Olle Grünewald and Ulf Johansson, Caroline Ahlstrand and Hans-Olof Hagén, Project Manager.

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Director General

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Contents

ICT investment, ICT use and productivity*

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Summary: Using UK and Dutch data on ICT use, ICT investment and firm performance, this paper considers whether the ICT usage variables collected in Ecommerce surveys are feasible predictors for missing ICT capital inputs. Furthermore, by embedding an augmented production function in a structural model, we investigate the contributions to productivity of ICT capital deepening and ICT use related TFP. Special attention is given to fast internet connectivity and Ecommerce. The results of the modelling exercise show that combining ICT usage variables collected in the Ecommerce survey and proxy measures for (total) capital inputs in a structural modeling framework can be seen as a useful approach for predicting missing ICT capital stocks, as well as for disentangling the productivity contribution of the two forms of ICT use in a direct (TFP) and indirect (through ICT capital deepening) component. For both countries we find evidence that, after controlling for IT investment, the productivity contribution of fast internet connectivity is channeled through ICT capital deepening. By contrast electronic selling seems to assert a direct impact on TFP.

1. Introduction

It is widely acknowledged that ICT has proven to be one of the most dynamic areas of investment as well as a very pervasive technology. The use of ICT can make firms more productive along different channels. It enables firms to customize services offered, to reduce inefficiency in the use of other inputs (e.g. by reducing inventories or by streamlining other business processes), or to seize spillover

* *This paper is based on Chapters 6 and 10 of Eurostat (2008) 'Information society: ICT impact assessment by linking data from different sources'. We thank Marina Rybalka of Statistics Norway for helpful comments.*

effects generated by ICT networks. These innovation-enabling characteristics make ICT a potentially important driver of productivity growth (see e.g. OECD, 2003 and OECD, 2004).

Notwithstanding the increasing and overwhelming empirical evidence presented on the impact of ICT on productivity (growth) in the past decade, the relative importance of different channels through which ICT affects productivity still leaves several questions open to debate. A recurrent question is how to disentangle the contributions of investing in ICT from its use given that ICT is often seen as a general-purpose technology embodied in a special type of physical capital and that making it productive also calls for complementary investments and special skills of its users.

A prerequisite for assessing the importance of the many factors that may play a role in explaining the contribution of ICT to productivity (growth) is the availability of sound data. Traditionally, growth accounting techniques have been employed to assess their contribution. Despite their virtue of simplicity, growth accounting methods – in general – cannot go further than quantifying the contribution of ICT capital deepening (i.e. the changes in ICT capital stocks per unit of labor) to TFP-growth at the industry level (see e.g. Van Ark et al. 2008 for a recent application). Moreover, applying growth accounting methods requires the availability of time series of ICT investment in hardware and software to construct ICT capital stock data.

Today, much of the empirical literature focuses on the contribution of ICT to TFP-growth, i.e. the unexplained residual of productivity (growth) that remains after capital deepening has been taken into account. Here, micro-econometric approaches come into play. By going down to the firm level and by using additional data sources this strand of research attempts to shed light on the 'ultimate causes' of TFP-growth. In principle, such a 'residual purifying' can only be achieved if data on capital inputs are available at the firm level. Otherwise one can have doubts whether these additional data variables really represent *TFP* contributions to productivity growth.

A problem often encountered in micro-econometric research concerns the lack of suitable data on capital stocks at the firm level. Constructing capital stock data at the firm level is seriously hampered by sampling in investment surveys or by the lumpiness of the investment process.[1] In addition, accounting for software investment in productivity research raises serious difficulties for several reasons

1 *Industry investment time series hide the fact that many firms do not invest every year. If firms were surveyed every year and data on initial stocks were available, this would not raise a problem as zero investment implies zero addition to the (gross) stock of capital. However, estimating initial stocks at the micro level is problematic because of incomplete and short investment histories.*

(see Clayton et al (2005)). This lack of data on ICT and other capital stocks on the preferred level of analysis hampers a fair comparison between econometric and growth accounting approaches. Amongst other concerns, it may be questioned whether alternative data are valid substitutes for missing data on (ICT) capital stocks.[2]

This paper elaborates on the above question by linking firm-level data on ICT use collected in the harmonized EUROSTAT survey (henceforth labeled *EC* survey) with estimates of ICT and other capital stocks derived from firm-level investment time series and accounting data on firm performance.

This paper seeks to address two main questions:

- Do particular forms of ICT use have an impact on productivity after ICT capital stock data are accounted for in the productivity models?
- Are the ICT use variables collected in the *EC* surveys feasible predictors of ICT capital stocks?

The linked data are used to investigate the relation between ICT use variables and ICT capital stock as well as the productivity impact of ICT use and ICT capital stocks. This is achieved by embedding an augmented standard production function framework in a structural model. As there are similar data in both countries this approach is feasible both for UK and for the Netherlands.

The plan of this paper is as follows. In sections 2 and 3 we discuss the research strategy followed and the empirical specifications applied in econometric part of this research. Section 4 discusses the data used. Section 5 presents the estimation results and elaborates on the feasibility of the *EC* variables for predicting (missing) ICT capital stocks. Finally, section 6 summarizes the most important findings. Appendices A and B present some further descriptive statistics of the Netherlands and UK datasets.

2. Motivation of the modeling exercise

A natural starting point for the discussion is a productivity model that accounts for ICT capital. Following Marilanta and Rouvinen (2003) and Farooqui (2005), we augment the traditional Cobb-Douglas production function model with a labor augmenting factor *E*, which is made ICT dependent, and Ecommerce Survey variables (denoted by *EC*) as possible determinants of *TFP*. In the absence of data on the composition of capital stocks this leads to

2 *It goes without saying that this problem also applies to non-ICT capital inputs.*

$$Y_{it} = A_{it} K_{it}^{\alpha} (L.E)_{it}^{\beta} \quad (1)$$

$$\ln(A_{it}) = F(EC_{it}, HC_{it}) \quad (2)$$

whereY is value added in constant prices, *K* is a measure of total capital inputs, *L* is labour inputs. *A* represents *TFP* and i and t refer to firms and time respectively. Equation (2) expresses that *TFP* (in logarithmic form) depends on a vector of firm and time specific *EC* and skill variables (labelled *HC*).

Marilanta and Rouvinen (2003) argue that the marginal productivity of labour should depend on whether employees use computers or not. In the Ecommerce Survey we have data available on the share of employees that use computers (*PCpct*). Thus, following their reasoning, we can specify *E* in (1) as

$$E = 1 + \theta PCpct \quad (3a)$$

Then, inserting (3a) in (1) and expressing (1) in per employee terms, yields after taking logarithms:

$$\ln(\frac{Y}{L})_{it} \approx \alpha \ln(\frac{K}{L})_{it} + (\alpha + \beta - 1)\ln(L)_{it} + \beta\theta PCpct_{it} + F(EC_{it}, HC_{it}) \quad (4)$$

where the approximation follows from $\ln(1 + \theta PCpct) \approx \theta PCpct$.

Another more direct route, conditional on the availability of IT capitals stocks, is to split up total capital inputs into ICT *(K^I)* and non-ICT capital inputs (K^R). Allowing their productivity contribution to vary and assuming constant returns to scale, yields the following linear specification for the productivity model:

$$\ln(\frac{Y}{L})_{it} = \alpha_1 \ln(\frac{K^R}{L})_{it} + \alpha_2 \ln(\frac{K^I}{L})_{it} + \widetilde{F}(EC_{it}, HC_{it}).^3 \quad (5)$$

Equation (5) represents the model usually applied to mimic growth accounting at the firm level with the aim to disentangle the ICT productivity contributions into capital deepening and *TFP* components. Equation (4) is used to clarify the main concern of this paper. In (4), θ represents the productivity premium from using ICT. If ICT is *not* a special type of capital and does not have an associated productivity premium then *PCpct* is redundant and F( ) can be interpreted as the contributions of ICT use to *TFP* conditional on including some measure of total capital inputs (K^P) in the model. This would also imply that it is no longer necessary to split total capital inputs into (K^I) and (K^R) in (5).

3 This specification is obtained after imposing .$\beta = 1 - \alpha_1 - \alpha_2$

Now, let us assume that ICT is a special type of capital. Then, omitting data on the relative importance of (past) ICT investment boils down to estimating (4) whilst excluding *PCpct*. In general, this is the approach followed in the regression part of the core analysis and in most other sub themes of the Eurostat ICT Impact project (see Eurostat, 2008). Notice, that if *PCpct* is (erroneously) omitted from (4), then *F*( ) can no longer be interpreted as a 'pure' *TFP* contribution to productivity of ICT use. In this case, estimates of indicators that refer to ICT use (lumped into *EC*) may be biased upwards as it is likely that they capture the productivity impact of an important omitted variable.

This problem will be more severe for those components of *F(EC, HC)* that are highly correlated with (missing)K^I. An example is the fast internet connectivity indicator *DSLpct*. This indicator is constructed as *DSLpct* = *DSL* • *PCpct*. It can be added to (3a) to account for the *additional* labour augmenting productivity impact of broadband enabling employees that use computers:

$$E = 1 + \theta_1 PCpct + \theta_2 DSL \cdot PCpct \quad (3b)$$

[4]

If (3b) instead of (3a) is used in (1) and PCpct is not included in the empirical specification (i.e. $\theta_1 = 0$ is assumed), then it is easily seen that the estimate θ_2 is likely to be biased upwards as it will capture the underlying impact of IT investment (either measured by *PCpct* or K^I). Thus, it is questionable whether the estimates of *DSLpct* after omitting *PCpct* really represent a 'true' *TFP* contribution to productivity of broadband connectivity[5]. Notice further, that *PCpct* seems to be redundant if data on ICT capital stocks per employee are available. In this case we can directly estimate (5) using our estimates of (K^I) and (K^R). The coefficient on *DSLpct* will then only capture the productivity premium θ_2 and not the capital deepening effect.

However, introducing IT investment as a separate input into production raises other problems. Several forms of ICT usage are likely to be highly correlated with IT investment. Furthermore, to get the best out of their IT investment, firms also need to have (unobserved) complementary investments in place, which, in turn, are also likely to be correlated with productivity (see e.g. Bresnahan et al., 2002, and Van der Wiel and Van Leeuwen, 2004).

4 DSL *is a binary indicator for having fast internet or broadband connections or not.*

5 DSLpct *is a derivative of PCpct. Correctly including both in a regression specification can lead to problems of multicollinearity that can incorrectly influence the significance of the variables. This is another reason for including IT capital stocks, if our real interest lies in assessing the productivity impact of broadband connectivity.*

Going beyond ICT measurement, a similar reasoning applies to other potential determinants of productivity differences across firms. Here, one of the 'usual suspects' is labour input. If the successful application of ICT requires better qualified labor inputs, then we face another simultaneity problem as variations in high qualified labor inputs will simultaneously explain productivity differences as well as differences in ICT intensity (use). In a similar fashion to many of the other regression models used in the Eurostat ICT impact assessment project, we are forced to use the wage rate as a proxy measure for skill differences between firms. Wages and productivity, measured using valued added, are highly correlated. Thus, the use of this *HC* indicator exacerbates the already existing simultaneity and causality problems.

In order to cope with these complications, we embed the productivity equation in a structural model that attempts to account for the simultaneity of productivity, IT investment, ICT use and skills and reverse causality for skills and ICT use. In addition, the system also enables us to look at the predictive power of the model for explaining per employee capital stocks.

3. The structural model

The availability of firm level data on ICT and non-ICT capital stocks and proxy measures for total capital inputs offers an interesting opportunity to investigate several of the issues discussed above. The structural model will focus in particular on high speed internet, connectivity (*DSLpct*), electronic buying (*Epurchpct*) and selling (*Esalespct*). In addition, we will also use the same ICT maturity indicators (*BI*) as given in the single equation framework presented in the Appendix of Chapter 6 of Eurostat (2008).[6] With these data, a system of estimation equations is constructed as follows:

I) Productivity equation (5) is augmented with the three EC variables, mentioned above and wages to proxy unobserved skills. After relaxing the familiar constant-returns-to-scale assumption used in growth-accounting, using small letters to denote logarithmic transformations and omitting firm and time subscripts, this yields:

$$y - l = \alpha_1(k^R - l) + \alpha_2(k^I - l) + (\alpha_1 + \alpha_2 + \alpha_3 - 1)l + \alpha_4 w + \alpha_5 Dslpct + \alpha_6 Esalespct + \alpha_7 Epurchpct + \sum_{j=8}^{13} \alpha_j BI_j, \qquad (6)$$

where w is the logarithm of wages per employed person;

6 BI is a set of dummy variables representing increasing stages of ICT maturity. The underlying Business Integration Index is constructed from a set of binary response variables referring to automated business processes. Further details can be found in Chapter 9 of Eurostat (2008).

II) next, we added equations for other capital inputs per employee inputs (7) and ICT capital inputs per employee (8):

$$k^R - l = \gamma_1 (k^P - l) \tag{7}$$

$$k^I - l = \eta_2 PCpct + \eta_3 WEB + \eta_4 DSL + \eta_5 Dslpct + \eta_6 Esalespct + \eta_7 Epurchpct + \sum_{j=8}^{13} \eta_J BI_j \tag{8}$$

and with k^P a proxy measure for total capital inputs and *WEB* a binary indicator for website use;

III) finally, the system is completed after including wage equation (9) to control for simultaneity and reverse causality between productivity, wages and ICT use:

$$w = \phi_1 L(w) + \phi_2 (y - l) + \phi_3 DSLpct \tag{9}$$

where *L(w)* represents lagged wage rates.

Equation (6) is a straightforward implementation of a standard Cobb-Douglas production specification that accounts for IT capital and IT use. As mentioned above equations (7) and (8) are capital stock prediction equations with a major focus on thoroughly describing possible determinants of IT capital stock. The wage equation (9) captures the idea that firms face sticky wage schedules, so that current wages depend on past wage bills and improvements in current productivity. We include *DSLpct* to reflect the fact that computer enabled employees embody higher skills and therefore command a wage premium.

By estimating (6) – (9) simultaneously, we attempt to free the parameters of the productivity equations from simultaneity biases as well as to predict ICT capital stocks per employee from the most important *EC* variables through equation (8). Notice further, that (7) is a prediction equation for non-ICT capital inputs per employee. We kept this equation simple by using the proxy measure of total capital inputs (k^P) as the only explanatory variable.[7] For identification purposes we do not include *EC* variables in this equation.

In closing, we mention that the simultaneous-equation approach opens several possibilities for hypothesis testing. An interesting question concerns the importance of the continuous *EC* variables for *TFP* in (6) as well as for explaining differences in ICT capital inputs in (8). For instance, if differences in *DSLpct* mirror differences in ICT capital inputs per employee, then one can expect its estimate

7 *For the Netherlands this proxy measure is deflated depreciation costs. For UK it is a mixture of depreciation rates and total capital stocks.*

in (6) to be smaller in a simultaneous model than when using a single-equation approach. Similar assertions can be made regarding the importance of *Esalespct* and *Epurchpct*. Thus, for instance, testing, $\eta_5 \neq \alpha_5$, $\eta_6 \neq \alpha_6$ and $\eta_7 \neq \alpha_7$ is an important objective of using the systems approach. Furthermore, this approach enables us to decompose the 'reduced-form' impact of single-equation estimation into a direct effect and an effect that is channelled through ICT investment. Take for instance *DSLpct*. The direct effect of an increase of *DSLpct* is given by α_5 and the indirect effect by $\eta_5\alpha_2$.

4. Data

4.1 The construction of unbalanced panels

In the empirical part of this paper we will use unbalanced panels consisting of firm-level data that constitutes the overlap of EC and PS surveys of the core analysis and the capital stock panel constructed with the help of investment surveys. The panel consists of about 11800 observations for UK and about 3900 for the Netherlands (firm x year, covering the period 2001–2005 for UK and 2002–2005 for the Netherlands). The accounting data cover, among others, the following key variables: gross output, total turnover, employed persons in full time equivalents, intermediate inputs, wage costs (including social security charges), depreciation costs and before-tax profits. The data enable the construction of value added as the measure of output.[8] In order to consider real outputs and inputs in our analyses, we use detailed price indices from the EUKLEMS database to construct value added in 2001 prices at lower levels of aggregation.

The panels contain interesting features, but are not completely perfect. Regular issues of sampling, coverage, and missing variables are at stake. The problem of missing variables arises for firm-level prices which are not available.[9] Problems of coverage arise because the average size of firms in the panel is considerably higher than actually measured for the total population of firms. In particular, in both countries the trade and service sector consists of many small firms and, due to sampling designs, many of them are only occasionally covered in the PS and EC surveys. The sampling probability increases with firm size and larger firms

8 *We could also opt for gross output (or total sales) as the measure of output, but we have chosen not to do so. The reason for this is that many firms belong to wholesale and retail trade. For these branches the data on intermediate inputs consist for a very large part of purchases of trading goods and this makes these data incomparable with the intermediate inputs of other branches.*

9 *This issue may lead to problems when measuring the impact of e-commerce on TFP. It has been shown (see Clayton & Criscuolo, 2002) that the use of e-procurement leads to competitive pressures on prices that result in lower prices of intermediates. Using industry level price deflators, as opposed to firm level prices, means that more cost efficient procurement is reflected in higher TFP. Similar concerns with the final price of outputs may lead to a negative coefficient on e-sales. A positive coefficient on e-sales therefore indicates that the true impact on TFP outweighs the pricing impact.*

are sampled every year, in principle. Nevertheless these larger firms may also disappear in the course of time because of bankruptcy, merging with other firms etc. Despite these complications, due to unique firm identifiers one can easily construct panel data linking the yearly surveys over time.

4.2 The construction of capital inputs

One of the objectives of this paper is to investigate the predictive power of EC variables for missing ICT capital stock data. For this reason we had to construct ICT capital stock data with the help of data on ICT investment (for UK including software investment) and data on ICT and other investment deflators. The procedures followed can be outlined as follows.

Netherlands

For the Netherlands we used the full detail of the investment surveys, combined with National Account price indices that are available for the different asset types, to construct real expenditures on ICT- and non-ICT investment. The ICT investment deflator used resembles the hedonic ICT price index used e.g. in the USA. Subsequently, capital stocks are constructed for 2000–2005 if we have available at least five consecutive observations on investment in constant prices in 1995 – 2000. We use this period to estimate initial stocks as a starting point for applying the perpetual inventory (PIM) method in later years. Accordingly, the capital stock K_{kt} of type k in period t reads:

$$K_{kt} = (1 - \delta_k)K_{it-1} + I_{kt-1} \qquad (10a)$$

Estimates for the unknown initial levels of the stocks in 1995 were obtained by using the approach of Hall and Mairesse (1995):

$$K_{k1} = \frac{I_{k1}}{g_k + \delta_k} \qquad (10b)$$

where g_k represents the pre-sample growth rate of real investment for type k, and I_{k1} is real investment in the base year. The problem of missing data on initial ICT investment (I_{k1}) is solved by using average investment in 1995–2000 as a starting point for the PIM estimates of ICT stocks.

Furthermore, the implementation of (10a) and (10b) requires a number of other assumptions concerning the pre-sample growth of investment and its depreciation. Estimates for g_k were taken from industry time series and for the depreciation schedule we used the inverse of the weighted average service life of the asset types considered. For the Netherlands weights were taken for the National Accounts estimates for Productive Capital Stocks by industry.[10]

10 *For ICT hardware a service life of four years was used.*

UK

UK IT capital stocks are constructed following closely the methodology laid out in Bloom, Sadun, Van Reenen (2007). In addition we improve the estimates of software capital by looking deeper into the issue of underreporting and missing values.

The ONS runs three separate surveys from which information on IT investment can be sourced. The Production Survey introduced a question on Purchased Software and another on Own Account Software in 2000. The Annual Business Survey on Capital Items (BSCI), which has a sampling frame of the largest 2500 firms, inquires about investment in hardware and software (both purchased and own account). Like the BSCI, the quarterly Capital Expenditure Survey (Capex) also collects information on hardware and software (purchased and own account) investment. It is sent out to 30,000 firms every quarter, and firms are rotated out of the sample every 5 quarters.

The sampling frame of all three surveys is designed so that the largest firms i.e. firms with more than 250 employees, are sampled by all three surveys every year. A small proportion of medium sized firms return more than one survey every year. This allows us to check the consistency of responses, across surveys, and use the best responses to construct the capital stock.

Comparing software investment responses in the Production Survey shows a general tendency of firms dramatically to understate own account software production. Of total software expenditure reported in the Production Survey, on average only 5% pertains to own account. Using this average, which we allow to vary across SIC4 industry and year, we adjust software investment responses from the BSCI and Capex to account only for purchased software.

Responses from the Capex are annualized and all three surveys are combed for missing values and data manipulations conducted by the survey teams, so that only clean firm responses are used in the construction of the capital stock. The three different surveys are then used to construct a separate data set for hardware capital and another dataset for software capital.

The hardware and software investment series are adjusted using economy wide asset specific hedonic price deflators provided by the National Institute of Economic and Social Research (NIESR), which are based on Jorgensen's US price deflators and have been harmonized to feed into the EU-KLEMS project.. Like the Netherlands we employ (10a) to calculate capital stocks from the real investment series.[11]

11 *We chose depreciation rates of 36% to reflect an average shelf life of 4-5 years.*

However our initial conditions (10b) differ. Instead of adopting the approach suggested in Hall and Mairesse (1995), we calculate industry level capital to investment ratios for each type of IT capital.[12]

The initial capital stock of a firm that has been sampled for the first time is determined through its industry level capital to investment ratio. Allowing this ratio to vary yearly, allows us to circumvent the influence of firm-specific investment cycles. The initial capital stock of a firm is calculated as follows:

$$K_{k1} = \frac{\overline{K}_{k1}}{\overline{I}_{k1}}.I_{k1} \qquad (10c)$$

where $\overline{I}_{k1}, \overline{K}_{k1}$ represent industry level real investment and capital stocks for type k, and I_{k1} is real firm level investment in the base year.[13]

12 *Industry level data on investment and capital stocks are also sourced from NIESR, see Timmer, O'Mahony, Van Ark (2007).*

13 *Total capital stock is constructed using investment series from the Production Survey and Capex. Initial conditions are imposed using the VIX-industry level dataset for all asset types. See Martin (2002) for further details.*

Table 1: Summary statistics for UK and the Netherlands

	UK	NLD
A All firms [a]		
Labor productivity (x 1000)	65[b]	68[b]
Employed persons (fte)	2236	319
Wage rate (x 1000)	21[b]	44[b]
	%	%
DSLpct	32	28
Esalespct	14	6
Epurchpct	6	5
B By sector (2005)		
Manufacturing and Construction		
DSLpct	32	34
Esalespct	26	8
Epurchpct	18	3
Distributive services		
DSLpct	37	37
Esalespct	16	11
Epurchpct	24	8
Other business services		
DSLpct	46	62
Esalespct	8	4
Epurchpct	17	6

[a] UK average for 2001–2005, the Netherlands average for 2002–2005.
[b] UK figures reported in GBP, Netherlands reported in Euro.

4.3 Some descriptive measures

Table 1 presents descriptive measures for some variables used in the model analyses. These statistics are calculated from the overlap between EC/PS panels and the capital stock panels. Thus, these descriptive statistics cannot be compared directly with the results of the core analysis of Eurostat (2008). What can be concluded is that the additional linking of capital stock data leads to data that are biased to larger firms. Furthermore, looking at how ICT is used, there are striking differences between the two countries. In particular, both electronic buying and selling seems to be much more important in the UK than in the Netherlands in all sectors considered. By contrast, the figures for fast internet penetration seem to be more comparable, except that broadband connectivity in other business services seems to be considerably higher in the Netherlands than in UK.

Because we link data on IT investment, our data consist of a subset of the firms used in the core analysis of Eurostat (2008). Nevertheless, we find very similar patterns for the correlation between broadband connectivity and labor productivity. Figure 1 shows that productivity is increasing with DSLpct on average, although the increase is more monotonous for NLD than for UK. The same conclusion also applies to the correlation between broadband connectivity use and wages (see figure 2), which is not a huge surprise, taking into account that wages and labor productivity are correlated too.

Figure 1: DSLPCT & Productivity 2005

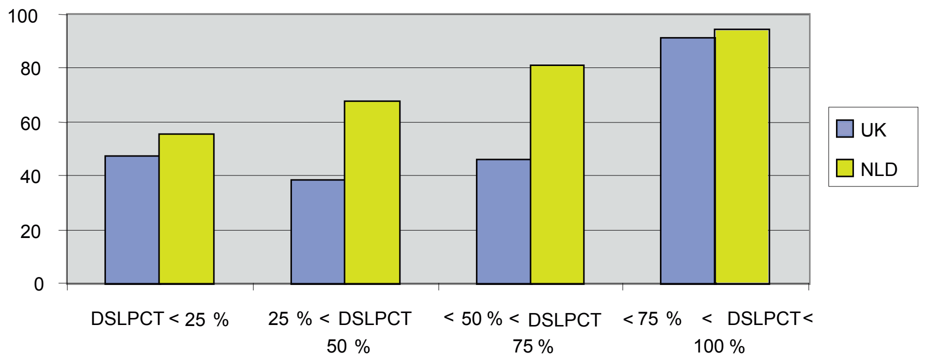

Figure 2: DSLPCT & Wages 2005

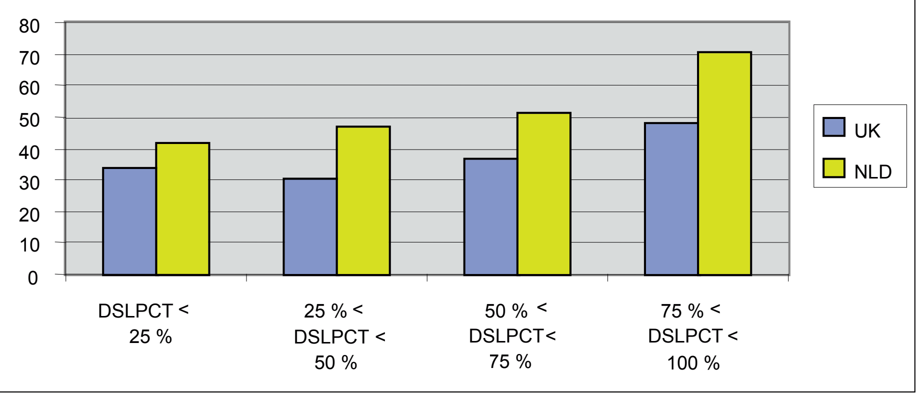

Table 2: Heckman model for ICT capital stocks

	NLD		UK	
I) Outcome equation	Est.	SE	Est.	SE
Proxy total capital inputs per employee				
Wage rate	0.725	0.060***	1.174	0.021***
Pcpct	1.131	0.082***	1.045	0.048***
Web	0.238	0.055***	0.104	0.048***
Dsl	0.001	0.053	0.046	0.033
Dslpct	0.423	0.090***	0.297	0.052***
Epurchpct	-0.079	0.121	-0.002	0.069
Esalespct	0.153	0.110	0.104	0.044***
Stage of ICT maturity (sellers perspective)	No		No	
Business Integration dummies	Yes	***	Yes	***
Constant	-2.879	0.253***		
SIC 2 digit dummies included	Yes		Yes	
Time dummies included	Yes		Yes	
N	3852		11717	
II) Selection equation				
Proxy total capital inputs per employee	0.019	0.013	0.032	0.010***
Employment	0.349	0.010***	0.386	0.009***
Dslpct	-0.029	0.046	0.174	0.033***
Esales	0.055	0.033	0.070	0.026***
Esalespct	-0.094	0.093	-0.018	0.046
Epurch	0.031	0.029	0.142	0.025***
Epurchpct	0.069	0.094	0.095	0.069
Constant	-1.999	0.087***		
SIC 2 digit dummies	Yes		Yes	
Time dummies	Yes		Yes	
Rho	-0.114		-0.523	
Sigma	1.092		1.265	
Mills ratio	-0.124	0.072	-0.662	0.060***
N probit	13573		17216	

5. Estimation results

5.1 Econometric issues

The linking of three data sources yields smaller data sets that seem to be biased to larger firms. This raises the possibility (but does not necessarily guarantee) that the firms that can be used to estimate key relationships between ICT investment, use and productivity, were performing significantly better in terms of productivity and/or were on average significantly more advanced in their ICT use. To safeguard against possible selectivity biases, the following route has been chosen:

- First, we estimate a Heckman selection model on each equation separately;
- Second, we evaluate the equation specific selection bias and capture in a new "mills bias" variable;

- Finally, we re-estimate all four equations jointly, in a system, adding the "mills bias" variable to the model specifications.

The procedure can be explained by looking at the ICT capital stock equation (8).[14] This prediction equation gives us the relationship between ICT use and ICT capital stocks per employee:

$$k^I - l = f(PCpct, WEB, DSL, DSLpct, Epurchpct, Esalespct, BI) + h(skills) + z(controls). \quad (8')$$

This equation can be estimated for a sub-sample of all Ecommerce firms (the firms with linked IT data). To correct for selectivity we have to use a selection equation:

$$D_{sel} = f(DSLpct, Epurch, Epurchpct, Esales, Esalespct, L, K^P) + z_D(controls), \quad (12)$$

with

$D_{sel} = 1$ if ICT capital stock data are available (otherwise $D_{sel} = 0$). The Heckman procedure boils down to estimating (8′) and (12) in 2 stages. The results of this procedure, the first step of the overall estimation process, are presented in Table 2.

The main equation of interest is (8′). The prediction equation gives us the relationships between the various forms of ICT use and how they impact IT investment decisions. For example, the positive and significant coefficient on *PCpct* in (8′) would suggest a capital deepening effect – giving a larger proportion of the workforce access to computers requires buying more computers or improved software that allows for a more time-efficient allocation of existing computers amongst the workforce. An insignificant coefficient on *WEB* would suggest that firms are able to create and maintain websites without necessarily increasing IT capital stocks.

But the relationships we uncover in (8′) are specific to the sample we are using. Are they representative of the larger EC/PS sample? Firms are selected for the estimation because we have data on capital stocks readily available. For all the other firms we have all the necessary data apart from capital stocks. What factors affect the probability of being a selected firm?

In the case of the Netherlands we know that we will have capital stocks for a firm only if that firm was sampled for five consecutive years between 1995–2000. But only the largest firms, in terms of employment, get sampled every year. Therefore, employment seems to be a factor that affects the probability of selection.

In order to run the productivity regression (6), we require data on both IT and Non-IT capital. For the Netherlands this overlap is perfect. The UK capital data

14 *The same procedure is followed for the other equations of system (6) – (9). To save space we do not discuss their results here (results are available upon request).*

come from two separate survey strands. Therefore the probability of being selected depends on whether a total capital stock figure exists for the firm in question. In this way (12) captures all the variables that may affect a firm's selection status. If larger firms really do use ICT differently from smaller firms then the core EC variables should also be a part of the selection equation. Other controls such as firm industry, region and sampling year in the EC survey is also taken into account.

Now that we have a way to estimate the probability of being selected[15] is there a way we can use this probability to re-weight the estimates in (8′) so that the results are more representative? We can think of the problem as akin to estimating an equation with a missing variable. Using the probabilities we have calculated in (12) we can construct a new variable that captures the omitted selection bias. Adding this variable as an extra control in (8′) therefore attempts to correct for the selection bias.[16]

5.2 Estimates for the simultaneous equation model

The appendix of Chapter 6 of Eurostat (2008) discusses the results of estimating (6) in a single equation framework. It shows how coefficients on the ICT use variables change as IT capital and wages (skills) are included in the regression framework. The changing pattern of estimates makes it difficult to draw conclusions on the role of the EC variables in explaining productivity differences. It is tempting to label the specification without wages as the preferred one, but this may not be wise, given that this specification omits the only available control for human capital.[17]

One can expect that the level of ICT use and (cumulated) ICT investment are broadly correlated by definition. This may also be the reason for the unstable results for the two capital elasticities in the single equation approach. The best way to investigate this issue is by using a structural model for the relation between ICT capital inputs and the ICT use variables. In what follows we discuss the results of using a simultaneous modeling approach that allows ICT use variables to have an impact on ICT capital inputs as well as on productivity.

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15 Estimation of (12) runs on the whole EC/PS sample accounting for both selected and non-selected firms.

16 Significance of this new variable – the mills bias – in (8′) indicates whether the smaller estimation sample suffers from selectivity problems.

17 Moreover, for the Netherlands, the sum of the two capital elasticities in this last result (Col. 3 – Table A3, Chapter 6 of Eurostat, 2008) remains rather small whereas the impact of other explanatory variables that refer to how ICT is used has increased at the same time.

The results of the simultaneous model are presented in Table 3. As mentioned above before estimating this model, we first investigate the selectivity issue by using Heckman models for each equation of the simultaneous model.[18] After adding Heckman selectivity correction terms (the inverse of the Mills ratio) to each equation, the system is estimated with the help of 3-SLS. Doing so, we allow for a possible correlation between the error terms of the equations.

Table 3: Estimation result structural models[1]

Equation	**NLD (N = 2015)**		**UK(N = 6384)**	
	Est.	SE	Est.	SE
(6) Productivity				
Non-ICT capital per employee	**0.242**	**0.021**	**0.116**	**0.011**
ICT capital per employee	**0.080**	**0.028**	**0.062**	**0.026**
Employment	0.086	0.057	-0.029	0.013
Wage rate	**0.673**	**0.044**	**0.857**	**0.037**
Dslpct	0.050	0.045	-0.058	0.033
Epurchpct	-0.029	0.056	-0.015	0.029
Esalespct	**0.126**	**0.059**	0.019	0.021
Constant	0.878	0.758		
Stage of ICT maturity	Yes		(+)	
Mills ratio Heckman model	0.332	0.266	-0.177	**0.098**
R^2 adjusted	0.399		0.573	
(7) non-ICT capital per employee				
Proxy for total capital inputs per employee	**0.629**	**0.021**	**1.025**	**0.001**
Constant	**3.185**	**0.089**		
Mills ratio Heckman model	**0.147**	**0.079**	**0.043**	**0.006**
R^2 adjusted	0.569		0.996	
(8) ICT capital per employee				
Pcpct	**1.462**	**0.116**	**1.345**	**0.064**
Web	**0.350**	**0.085**	**0.150**	**0.071**
Dsl	-0.020	0.082	-0.006	0.046
Dslpct	**0.367**	**0.126**	**0.483**	**0.069**
Epurchpct	0.254	0.167	-0.023	0.088
Esalespct	0.096	0.150	**0.138**	**0.060**
Business Integration	**Yes**		**Yes**	
Constant	-0.046	0.229		
Mills ratio Heckman model	-0.056	0.111	**-1.520**	**0.102**
R^2 adjusted	0.311		0.310	
(9) Wage rate				
Productivity	**0.656**	**0.018**	**0.389**	**0.031**
Wage rate t -1	**0.202**	**0.021**	**0.393**	**0.014**
Dslpct	**0.047**	**0.017**	**0.052**	**0.017**
Constant	**0.348**	**0.071**		
Mills ratio Heckman model	0.063	0.016	**0.134**	**0.028**
R^2 adjusted	0.764		0.750	

1 All equations use time and industry dummies;
Estimates printed in bold are significant at the 1 % or 5 % level.

18 For the sake of brevity we omit the Heckman stage results for the productivity and wage equations. Tables are available on request.

A most notable result of the structural modeling approach compared to the result of the single-equation model (see Tables A2 and A3 from Appendix to Chapter 6 of Eurostat, 2008) is that the capital elasticities increase for the Netherlands, but remain relatively stable for the UK. Taking into account the standard errors of the estimates, this increase appears to be more substantial for the estimate of non-ICT capital inputs than for ICT capital. Furthermore, the sum of the two elasticities now allows a better comparison with the capital deepening effect found in growth-accounting studies. However, the estimate for Broadband intensity use (*DSLpct*) becomes insignificant, whereas the estimates for the two Ecommerce variables are fairly comparable to the results of the single equation approach, with again only *Esalespct* significantly different from zero.

Looking next at the ICT capital prediction equation of the model, it can be seen that the most important *EC* variables are also the most important determinants for explaining differences in ICT capital stocks per employee. The estimate for the share of PC enabled personal (*PCpct*) is sizable and highly significant, for both countries. The same conclusion applies to the estimates for the business integration indicators and for broadband connectivity (*DSLpct)*. This last result suggests that the productivity contribution of broadband use is channeled through ICT capital deepening, rather than through *TFP*.[19]

The structural system of equations reveals that the impact of *DSLpct* on productivity is routed through its indirect effect on ICT capital. This leads us to conclude that 'investment' in *DSLpct* is a form of ICT capital deepening. However, we draw attention to the to the fact that the significant coefficient on *DSLpct* in the ICT capital prediction equation represents a contribution of broadband connectivity to productivity via ICT capital deepening over and above that already captured by *PCpct*. In Chapter 12 of Eurostat (2008), it is shown how *DSLpct* plays a role as a determinant of innovation input and how differences in DSL usage are related to differences in knowledge sharing and integration with external parties through improvements in *DSLpct*.

Once the ICT capital stock has been quality adjusted for this deepening in knowledge capital, the direct impact of *DSLpct* is no longer significant. These results support the idea that improvements in *DSLpct* should be viewed primarily as improvements in a labor augmenting technology, with a secondary (indirect) impact on overall TFP. Secondly, the results prescribe the use of *DSLpct* as a proxy for knowledge capital when the IT capital stock under consideration does not account for this particular aspect.

19 *The estimate of DSL is in the ICT capital equation is insignificant. Which may not be very surprising as its impact is captured by broadband intensity use.*

By contrast, the estimate for electronic sales (*Esalespct*) in the ICT capital equation is insignificant for the Netherlands, and although it is positive and significant for the UK, other variables seem to have a bigger impact on ICT capital deepening. Comparing this result with the corresponding estimate of the productivity equation, this suggests that the positive productivity impact of electronic sales found in the productivity equation represents a *TFP* effect primarily.

The simultaneous model uses the wage rate as a control for skill differences in the productivity equation and uses a wage equation to account for joint endogeneity of skills and productivity and the possible reverse causality for broadband adoption and productivity. The results of Table 3 show, as one could expect, that wages (skills) are highly correlated both with productivity and broadband intensity use. This last result confirms the existence of computer wage premiums found in earlier research (see e.g. Krueger, 1993, and Muysken et al., 2006).

Table 4: Estimation result structural models after using predicted capital stocks[1]

Equation	NLD (N = 6016)		UK (N = 9645)	
	Est.	SE	Est.	SE
(6) Productivity				
Non-ICT capital per employee	**0.181**	**0.01**	**0.128**	**0.006**
ICT capital per employee	**0.068**	**0.01**	**0.061**	**0.005**
Employment	**0.006**	**0.00**	0.019	0.015
Wage rate	**0.831**	**0.01**	**0.812**	**0.013**
Dslpct	0.008	0.01	-0.000	0.027
Epurchpct	-0.021	0.03	-0.015	0.041
Esalespct	**0.112**	**0.03**	**0.079**	**0.027**
Constant	**0.572**	**0.04**		
Stage of ICT maturity	Yes		Yes	
R^2 adjusted	0.601		0.574	

[1]All equations use time and industry dummies;
Estimates printed in bold are significant at the 1 % or 5 % level..

5.3 Imputing values for missing capital stock data

An interesting question of this research project concerns the predictive power of *EC* variables for estimating missing data on (cumulated) ICT investment or ICT capital stocks. This has been investigated further with the help of the estimates of the ICT capital prediction equation (8′). Recall that capital stock data were available for 3852 Dutch firms. However, as a result of using lagged wages, the structural model could only be estimated on the data of 2015 Dutch firms.[20] A complete set of predictors (covering all equations of the structural model) is available for 6016 Dutch firms. Similarly the structural model could only be

20 *This loss of data illustrates that many (small) firms are not sampled consecutively in the Ecommerce and PS surveys.*

estimated using 6384 UK observations, but a complete set of predictors is available for 9645 UK observations.

Thus, the capital equations of the model can be used for the imputation of ICT and non-ICT capital stocks per employee for 2164 Dutch and 3261 UK firms. Notice that these observations are imputed once corrections have been made for selection bias (via the Heckman model for selectivity) and the endogeneity between skills, ICT use and productivity. Because the estimated predictions of these stocks have been cleaned, productivity assessments that use the new imputed stocks can now be made through a single equation specification.

To assess the predictive power of the model for the imputation of missing capital stock data (ICT and non-ICT) we re-estimate the productivity equation (6) using the larger sample of 6016 Dutch and 9465 UK observations.

The results of this exercise are presented in Table 4. A comparison of Table 4 and 3 shows the predictive power of the model. The elasticity of the new ICT capital stock remains robust to the inclusion of the originally missing observations and at around 6% is strikingly similar for both countries. For reasons mentioned above, the coefficient on *DSLpct* is no longer significant in either set of data. However, the impact of electronic sales, although slightly higher in the Netherlands, is also remarkably similar for both countries and in the range of 8% – 11%.

This last result underlines that combining ICT use variables collected in the Ecommerce survey and proxy measures for (total) capital inputs in a structural modeling framework can be seen as a useful approach for predicting missing ICT capital stocks, as well as for identifying the productivity contributions of the different forms of ICT use and capital deepening.

5.4 Comparing the ICT use impacts derived from different models

Taking stock, and using the estimates of the various models, we can look at the direct and indirect effect of increasing several ICT use variables. From the continuously measured *EC* variables of interest *Epurchpct* remains insignificant in all models. For this reason, we restrict the discussion to *DSLpct* and *Esalespct.* Tables 5a and 5b summarize the results for the Netherlands and UK.

In the single-equation (OLS) approach of the Appendix to Chapter 6 of Eurostat (2008) there is no distinction between a direct and indirect effect. Here the estimates for *DSLpct* and *Esalespct* can only be interpreted as the direct contribution of broadband connectivity and electronic sales to *TFP*. Tables 5a and 5b show that these contributions can be very substantial for *DSLpct*, varying between 0.6% and 0.8 %. However, using the system estimates, it is shown that this contribution is biased upwards. This is so because the estimate of *DSLpct* in the single-equation approach captures the effect of ICT capital deepening if no information concerning (cumulated) IT investment is taken into account in the estimation procedure.[21] Nevertheless, the indirect effect of *DSLpct* on ICT capital deepening cannot be neglected. It is surprisingly similar for both countries and approximating 0.3 %.

By contrast, and irrespective of using a simultaneous or single-equation approach, it can be seen that using ICT for electronic sales lead to higher *TFP*-levels. Again the impact of electronic sales on TFP is surprisingly similar for both countries and in the range of 0.4 – 0.6 % in the simultaneous model. For the Netherlands, electronic sales only directly impacts TFP, whereas in the UK a very small but significant proportion is also channeled through ICT capital deepening.

Table 5a: Direct and indirect contributions to productivity of ICT use (NLD)[1]

Broadband connectivity(DSLpct)

	$\alpha(5)$	$\alpha(2)$	$\eta(5)$	$\alpha(2).\eta(5)$	ΔX	CD	TFP	Total
OLS-1[2]	0.063				10		0.6	0.6
OLS-2[3]	0.082				10		0.8	0.8
3-SLS N = 6016[4]	0.008(ns)	0.068	0.367	0.025	10	0.3	ns	0.3

Electronic sales(Esalespct)

	$\alpha(6)$	$\alpha(2)$	$\eta(6)$	$\alpha(2).\eta(6)$	ΔX	CD	TFP	Total
OLS-1[2]	0.148				5		0.7	0.7
OLS-2[3]	0.165				5		0.8	0.8
3-SLS N = 6016[4]	0.112	0.068	0.096(ns)	0.000	5	ns	0.6	0.6

[1] ns denotes not significant at the 1%, 5% or 10% level;
[2] OLS model that does not account for differences in the composition of capital stocks;
[3] OLS model that uses data on the composition of capital stocks but ignores the simultaneity of wages and productivity. Results taken from appendix of Chapter 6 of Eurostat (2008).
[4] Based on the single equation OLS estimation of productivity using predicted capital stocks from the 3-SLS estimation technique. Results taken from Table 4.

21 *The OLS results for fast internet connectivity in the Appendix of Chapter 6 of Eurostat (2008) are almost the same as obtained in the core analysis and after using wages to control for a skill related technological bias.*

Table 5b: Direct and indirect contributions to productivity of ICT use (UK)[1]

Broadband connectivity(DSLpct)

	$\alpha(5)$	$\alpha(2)$	$\eta(5)$	$\alpha(2).\eta(5)$	ΔX	CD	TFP	Total
OLS-1[2]	0.055				10		0.6	0.6
OLS-2[3]	0.038(ns)				10		0.4(ns)	0.4(ns)
3-SLS N = 9645[4]	-0.00(ns)	0.061	0.483	0.029	10	0.3	ns	0.3

Electronic sales(Esalespct)

	$\alpha(6)$	$\alpha(2)$	$\eta(6)$	$\alpha(2).\eta(6)$	ΔX	CD	TFP	Total
OLS-1[2]	0.138				5		0.7	0.7
OLS-2[3]	0.128				5		0.6	0.6
3-SLS N = 9645[4]	0.079	0.061	0.138	0.008	5	0.1	0.4	0.5

[1] ns denotes not significant at the 1%, 5% or 10% level;
[2] OLS model that does not account for differences in the composition of capital stocks;
[3] OLS model that uses data on the composition of capital stocks but ignores the simultaneity of wages and productivity. Results taken from appendix of Chapter 6 of Eurostat (2008).
[4] Based on the single equation OLS estimation of productivity using predicted capital stocks from the 3-SLS estimation technique. Results taken from Table 4.

Summing up: taking into account simultaneity and joint endogeneity, we obtain similar results in both countries (ranging from 0.8 % to 0.9 %) for the joint contribution of both forms of ICT use to productivity. Moreover, in both countries it is found that the impact of *DSLpct* is primarily channeled through ICT capital deepening, whereas electronic sales directly impacts *TFP*.

6. Conclusions

This paper elaborates on the use of ICT capital stock data for improving our understanding of the contribution of *EC* variables to productivity. A structural modeling approach has been compared with the results of reduced-form single equation estimation in order to disentangle the contribution of *EC* variables to ICT capital deepening and *TFP*. ICT can raise productivity either by (ICT) capital deepening or more directly via improving *TFP*. The variables collected in the Harmonized Ecommerce Surveys may point in both directions. Some of the variables seem to be closely related or complementary to ICT investment, others focus on how ICT is used and assessing their role calls for a simultaneous approach which models their relation with ICT investment as well as productivity. As a by-product we can also investigate the predictive power of EC variables for explaining differences in the stock of ICT capital per employee.

The results show that using a simultaneous model makes sense. This model yields plausible values for the elasticities of the estimated capital stock. Moreover, it is shown that some variables are more closely linked to ICT investment than others. For instance, enabling more employees with broadband connections seems to assert a productivity impact via capital deepening, because – after controlling for endogeneity and reverse causality – it is insignificant in the productivity equation, but very significant in the ICT capital equation. In conjunction with the results from Chapter 12 of Eurostat (2008), we posit that the capital deepening captured by high-speed broadband connections is in fact deepening in knowledge capital.

By contrast, the E-commerce variables are not important for explaining differences in ICT capital per employee. Nevertheless, an increase in electronic sales appears to have a strong and significant contribution to labor productivity via *TFP*, a result that appears to be rather robust to the various specifications applied. Another robust result is that no productivity impact of electronic buying could be found, irrespective of the model used. The level of ICT integration also seems to be more important for explaining ICT capital stocks than for explaining productivity.

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Appendix A1: Summary statistics for capital stock data for the Netherlands

Table A1 reports selected summary statistics for the Netherlands concerning the construction of capital inputs used in the econometric part of this paper. The unbalanced 'Capital Stock' panel consists of 3852 firms for which capital stock data could be constructed in 2000–2005 and that could be linked to the EC/SBS panel. In terms of output (value added in 2002) the balanced panel represents nearly 46% of all firms used in the core analysis of Eurostat (2008). This relatively low coverage ratio is mainly due to the fact that the smallest firms have low inclusion probabilities and, thus, are not surveyed consecutively. However, their contribution to aggregate capital stocks appears to be rather stable as the growth rates for capital inputs are comparable to those found at the aggregate level.

According to Table A1, ICT stocks grew at an average rate of 11.3% per year in the short period considered, a result that is much higher than for other capital inputs. Furthermore, it can be verified that the shares of ICT capital in total capital are markedly higher in the trade and service sector than in manufacturing and construction.

Table A1: Summary statistics for ICT and total capital inputs

	2002	2005
A Share of ICT in total capital stocks [a]		
Manufacturing and Construction	4.0	4.8
Wholesale and retail trade	7.6	11.0
Business services	5.4	9.7
All firms	4.8	6.6
B Annualized growth of capital stocks, 2002–2005[a]		
ICT capital stocks		11.3
Total capital stocks		1.1

[a] Calculated on the bases of totals

Appendix A2: Summary statistics for capital stock data for the UK

Table A2 reports selected summary statistics for the UK capital stocks used in the econometric estimations of this paper. The UK IT capital stock consists of two individual series that capture hardware and purchased software capital separately. The overlap between the two series is large and for years 2000–2005 we have approximately 40,000 firm-year observations for which a total IT capital stock, i.e. hardware and purchased software, can be constructed. However, only 11717 of these firm-year observations can be linked to the EC survey.

The overlap shrinks even more once we include total capital stock, which is constructed from another series of survey returns. Eventually we are left with

6872 observations, for years 2000–2005, for which we have data on IT and Non-IT capital stock and EC returns.

In terms of value added in 2002, these 6872 observations represent nearly 60% of all firms used in the UK core analysis of Eurostat (2008). According to Table A2, ICT stocks in the UK sample grew at an average rate of 18.5% per year over the short period considered, compared to growth rate of 10.3% for other capital inputs. These aggregate growth rates seem to be fairly representative: not only are shares of ICT capital in total capital higher in the trade and service sectors compared to manufacturing and construction, but also these shares have been growing apace.[22]

Table A2: Summary statistics for ICT and total capital inputs

	2002	2005
A Share of ICT in total capital stocks [a]		
Manufacturing and Construction	1.0	1.1
Wholesale and retail trade	4.3	5.5
Business services	1.7	2.2
All firms	2.1	2.7
B Annualized growth of capital stocks, 2002–2005[a]		
ICT capital stocks		18.5
Total capital stocks		10.3

[a] Calculated on the bases of totals

Appendix B1: Distributions for core variables for the Netherlands

Table B1 presents some descriptive measures for the variables used in this model analyses. Most of the variables are calculated from the overlap between EC and PS surveys. Thus, these distributions can be compared with the results of the core analysis of Eurostat (2008). The distribution of the variables that are also based on the capital stock panel adds to the insight of what is behind the weighted averages of Table A1. In spite of the fact that computers are everywhere nowadays, there still appears to exist a large dispersion in their relative importance, measured either by the share of ICT capital in the total capital stock or by ICT capital stocks per employee.

Of the firms that apply Ecommerce only relatively few appear to have realized substantial degrees of electronic sales and/or electronic buying. This general picture also emerges for the distributions of the same variables after matching the EC/PS panel with the Capital Stock panel. However, even though there are relatively more larger firms in this smaller data set, it cannot be concluded that

22 In absolute terms the shares of ICT capital in total capital are much lower in the UK than in the Netherlands. This is likely to be a reflection of a greater degree of under-reporting, in the UK, of IT investment relative to investment in other types of capital.

these firms, that are used in the modeling exercise, were performing significantly better in terms of productivity or were, on average, significantly more advanced in their ICT use.[23]

Table B1: Distribution statistics core variables 2002 and 2005 (NLD)

	p25	Mean	Median	p75
I) 2002 (N EC/SBS = 3969)				
Employment	19	174	44	138
Productivity	34.7	68.1	46.8	64.6
Share ICT capital	1.7	12.1	4.7	14.6
ICT capital per employee x 1000EUR	1.1	5.4	2.9	6.4
WEB		74.7		
DSL		49.4		
Esales		35.1		
Epurch		44.6		
Pcpct	20.0	53.1	50.0	98.0
Interpct	5.0	35.2	20.0	60.0
DSLpct	0.0	23.6	0.0	35.0
Epurchpct	0.0	5.1	0.0	1.0
Esalespct	0.0	5.0	0.0	0.0
II) 2005 (N EC/SBS = 3216)				
Employment	27	230	77	212
Productivity	38.3	72.1	52.1	71.9
Share ICT capital	2.8	15.6	7.5	20.7
ICT capital per employee x 1000EUR	1.1	8.5	5.4	11.2
WEB		90.2		
DSL		91.0		
Esales		34.4		
Epurch		57.3		
Pcpct	30.0	61.3	65.0	100.0
Interpct	15.0	46.6	36.0	80.0
DSLpct	10.0	44.0	33.0	80.0
Epurchpct	0.0	5.5	0.0	2.0
Esalespct	0.0	6.0	0.0	0.1

Appendix B2: Distributions for core variables for the UK

Table B2 presents descriptive statistics for the EC variables used in the UK analyses. Firms in the UK sample are on average much larger than in the Netherlands. However trends in ICT use seem to be roughly comparable. According to the un-weighted averages, both countries have witnessed a sharp increase in ICT intensity. Almost all firms in both countries have a website. More striking differences arise when we consider individual uses of ICT. Growth in high-speed internet use has been more pronounced in the Netherlands, whereas a much

23 *For* PCPct, Interpct *and* DSLpct *the means of the distributions of the matched EC/PS/Capital stock panel for 2005 were 61%, 41% and 40% respectively. The mean of* Esalespct *was 7.2% in 2005..*

larger proportion of UK firms have introduced e-sales and e-procurement into their business processes.

By 2005, 55% of firms in the sample had e-sales systems in place. Nearly 85% of firms were operating e-procurement systems.[24] Firms using e-commerce systems in 2005 were selling, on average, 17% through e-sales and procuring almost 20% through e-purchases.[25]

Similar patterns emerge in the distributions of the core variables after matching the EC/PS panel and the Capital Stock panel.[26] However, this smaller data set is slightly more biased towards larger firms, and unlike the Netherlands, this does lead to issues of selection bias in the UK data.

Table B2: Distribution statistics core variables 2002 and 2005 (UK)

	p25	mean	median	p75
I) 2002 (N EC/SBS = 2847)				
Employment	150	1520	404	1278
Productivity	17.5	52.9	28.9	47.0
Share ICT capital	0.4	3.2	1.3	3.6
ICT capital per employee x 1000GBP	0.2	2.0	0.6	1.7
WEB		89.7		
DSL		63.9		
Esales		43.6		
Epurch		55.2		
Pcpct	20	49.0	45	80
Interpct	5	32.9	20	55
DSLpct	0	25.4	8	40
Epurchpct	0	1.5	0	0.1
Esalespct	0	13.6	0	10
II) 2005 (N EC/SBS = 3587)				
Employment	179	1594	438	1297
Productivity	17.3	55.7	30.4	51.9
Share ICT capital	0.6	3.9	1.7	4.2
ICT capital per employee x 1000GBP	0.3	2.1	0.8	1.8
WEB		94.8		
DSL		83.0		
Esales		55.0		
Epurch		84.5		
Pcpct	25	57.8	60	90
Interpct	12	45.2	38	80
DSLpct	5	37.7	25	70
Epurchpct	0.1	20.3	5	25
Esalespct	0	17.0	0.5	20

24 *Compared to 34% and 57%, respectively, for the Netherlands.*

25 *Compared to 6% and 5.5%, respectively, for the Netherlands.*

26 *Sample period, 2001–2005, averages for* DSLpct, Esalespct *and* Epurchpct *in the EC/PS overlap were 30%, 13.9% and 2.9% respectively. In the EC/PS/IT overlap these were 32%, 14.3% and 5.9% respectively.*

Table B2 also presents a more detailed distribution of the UK IT capital stock adding more insight to what is behind the weighted averages of Table A2. The similarities in ICT use intensity between the two countries contrast sharply with the differences between measures of IT capital stock, suggesting again that UK investment surveys suffer more from under-reporting of IT investment.

ICT use, broadband and productivity

Hans-Olof Hagén, Jennie Glantz and Malin Nilsson[1]

Why we have made this study and what we have found

Impact studies are not meaningless

We are now very far away from the situation when Robert Solow made his famous comment on the empirical base for the productivity effects of ICT. Now there is considerable empirical evidence of the importance of ICT for productivity. This is true for studies on the national and the industry level as well as on the firm level. One of the largest and most up to date studies is"Information Society: ICT impact assessment by linking data from different sources", Tony Clayton et.al (2008).

In this study we will try to add to that knowledge base. However, there is the question of the value of analysing the impact of the ICT use. There is an ongoing principal discussion about the impact of firm's uptake of different practices, like ICT. One view is that good firms with good managers do most things in a better way, including use new practices at the right time. This makes studies of the impact of innovation, new management practices, work organisation and ICT use meaningless, since the good firms are much better in many other ways which are and can not be measured.

The other view is that no one is perfect and people and firms are good at different things due to their historic situation, their manager and the staff they possess. According to this view it is meaningful to investigate the relationship between some practices and the performance of the firms. Still, it is of course necessary to take into account other facts that could influence the firm's performance, like industry, size, being part of a group, the staff quality and most important its past performance.

1 *This paper is partly based on two master theses by Jennie Glantz, Glantz (2008), and Malin Nilsson, Nilsson (2008) at Stockholm University.*

We agree with the second view and firmly believe in the meaning in conducting impact studies; we believe in the consequences of the value of collecting this kind of information from firms, even if it at many times is difficult for them and a real effort is needed to answer these kinds of questions. In the today's world it is ICT, innovation, human capital, work organisation and other intangible assets that are most important for firm performance. It is also equally important to economic growth and living standard and thus to policy.

In this study there are two different focuses: the first is on broadband and its relationship with ICT use and productivity and the second is on the relationship between the general ICT use of the firm and its economic performance. *The broadband focus is in turn split into two parts: first we will try to find out what comes first - the chicken or the egg: That is, if it is broadband access that triggers an intensive ICT use or if it is primarily the firm with heavy ICT use that acquires broadband. Then we move on to study the whole chain: broadband-ICT use-productivity. Finally we will also study the direct link between ICT use, whatever triggers it and productivity.* The empirical base for this study is a panel database with the Swedish version of the Eurostat E-business surveys for the firm ICT use 2001-2005 and register data on balance sheets and staff composition for the years 1998-2005.

Broadband and ICT use improve firm productivity

In 2005 almost 90 percent of the firms in the survey had broadband and even more have it today. However, even if most companies in Sweden already have broadband, it is still of interest to find out which variables affected the company's decision to acquire it, since the speed of Internet connections are increasing and the same factors that influenced the decision to acquire it will probably be in place for explaining which firms are most willing to get higher and higher speed. It is also of interest to see what characterises a company with broadband and the effect of higher speed on the ICT use.

The estimations confirm the hypothesis that the influences between broadband and ICT use go both ways. But since speed has a significant effect on IT level every year, it is obvious that firms with a high IT level probably have a fast Internet connection. This means that if a company increases its Internet connection and gets broadband it is most likely to increase its Internet use by more than if it did not acquire broadband. The arrow that points in the other direction is not nearly as strong.

The estimations have also shown that in most cases there seems to be a positive relationship between broadband and productivity. Broadband gave a significant impact on the ICT use in every dataset, and for most of the years the ICT use (ITLevel) also has a positive significant impact on productivity.

Finally the direct link between ICT use and productivity was analysed. First a simple test was done to shed some light on the controversy, if it is the good companies that use ICT extensively or if it is heavy ICT users that perform well. This test gave a clear indication that even if productive firms use ICT more intensively the indications are that much stronger that the firms that use ICT heavily are inclined to be more productive in the future.

In order to get more conclusive answers, estimations were performed when different factors like: industry, size, internationalisation, time, human capital and past productivity were taken into account. The results were quite clear: the ICT use of a firm gave a significant effect on the firm's productivity even if it seems to take some time before the whole effect materialises. This effect also proved to be quite stable irrespective of specification of the productivity. This means that the ICT use gave a boost to the productivity however this was measured. *The conclusion is: ICT use improves firm productivity.*

The empirical base for the study

Indicator on ICT use

The Eurostat survey E-business, which tries to capture the firm's ICT standard and its ICT use, is the source for the ICT indicators used in this paper. These questions give many options for describing the ICT use of a firm, so no choice is self evident.

However, ICT use is a complex process with many links between the different uses. If a single activity is selected and put in a regression and becomes significant, the interpretation of the result will most likely be exaggerated. The firms that use ICT in this way are probably also using it in other ways, so the regression results reflect the effect of these combinations and not of just the single activity. The only possibility to avoid this problem is to accept the fact that ICT use comes in bundles and create measurements that capture this phenomenon and use these measurements instead of single variables. This is of course no easy task and it will be highly questioned, since there is no apparent way to make such bundles.

These kinds of composite indicators are created by adding activities that are measured in quite different ways. It is like composing fruit baskets with different fruits and trying to decide which fruit basket is the most attractive. To one person who does not like oranges, it does not matter how many oranges you put into the baskets; it will not become more attractive to that person, but to many others it will make a difference. Weighing together different indicators of ICT use is even more challenging; the only comfort is that most broad composite indicators will probably rank firms in similar order.

The ITLevel

In this context a broad composite indicator has been created based on the Eurostat E-business survey from 2002-2006, which actually measures the situation for the years 2001-2005. To include the year 2001 is a little problematic since the relevant questions were substantially fewer that year. The broad indicator which has been used in this study is based on four different aspects of the firm's ICT use: Internet use, business system integration, purchase and sales on electronic channels (mainly the Internet).

The four components;

- ***Internet use*** = Number of business activities
- ***Business system integration level*** = types of activities integrated with orders and purchase systems

- ***Online purchasing*** in percent of total purchase both on Internet and EDI (electronic data interchange)
- ***Online sales*** in percent of total sales on Internet and EDI

ICT level = Internet use indicator + business system integration level indicator + online purchasing indicator + online sales indicator

Internet use

The different Internet activities are the following in the 2002 E-business survey: general information, analysis of competitors, financial transactions, providing service and support, downloading digital content and finally staff education. As can be seen the actual question has varied substantially over the years. For all the years they have been converted to a 0-100 scale.

Business system integration level

An important step in getting more out of the ICT investments is the integration of different parts of the firms' ICT system and between the firm and its customers and suppliers. This is clear from *Kazuyuki Motohashi,* Motohashi (2006), recent research on Japanese data "Firm-level analysis of information network use and productivity in Japan". He defines different steps in the firms' ICT development process, where the second last is the integration within the firm and the last one is the integration between the firm and other firms. Some of his conclusions are:

"In this paper, the dynamic process of a firm's introduction of IT and the heterogeneity of performance impact by type of application are also investigated. A great number of firms began and then ceased using information networks during a period in the 1990s. It was found that firms abandoning IT network use, performed poorly compared to those who maintained such systems. This finding suggests that IT will not save all firms, but for those which have a complementary asset, the positive impact of IT can be clearly observed. It should also be noted that the impact of networks on productivity differs significantly by type of application, by period or by sector (manufacturing or wholesale/retail trade), which suggest that this complementary asset is heterogeneous in terms of methods of IT use.

Finally, we looked at a firm's collaborative activities with others, as one of the variables reflecting complementary assets, and evaluate complementarity in terms of inter-firm information networks. It is observed that a firm undertaking both collaborative activities and participating in inter-firm networks performs better than a firm that performs only one such activity. This pattern of complementarity is particularly seen in collaborative R & D, which involves substantial coordination between firms."

Also Peter Goodridge and Tony Clayton, Clayton and Goodridge (2004), have got similar results from the English data based on the E-business survey. Some of their conclusions are:

"Electronic business process management is becoming an established practice for UK firms of all sizes. Firms using e-business integration tend to apply it in a number of areas introducing automation through the enterprise. These firms, on average, tend to be more productive than firms that do not apply ICT in this way."

These and other findings lead us to believe that the information on the firm's business process integration that is available in the E-business survey should be used in our analysis. The business system integration activities that are integrated with the firm's order and purchase system which are specified in 2003 E-business survey are: internal system for reordering, pay system, production, logistics, marketing, customers and suppliers.

There are two principal different alternatives to construct an indicator: one is based on both the internal and external integration and the other just on the external integration. The result from the Japanese study speaks for the first alternative and also the simple correlations and regressions on the Swedish data from 2002 and 2004. The correlation with productivity is quite significant for most components of the internal as well as the external part of the questions. This means that the integration between the firms' order system and other systems within the firm, like production and payment, is important as well as the integration with their customers and suppliers. And a regression with a composite indicator based on both can explain a lot of the variance in the gross production multifactor productivity then controlled for industry. The British study speaks for the second alternative, but it is based only on the external integration probably due to lack of data on the internal integration for some years and countries.

There is in principle one question that can be used, which has been changed somewhat over the years[2]. If all alternatives are used, this is the maximum number that a firm can reach is on a composite indicator that is a simple counting of the alternatives. Also this question has varied over the years. This indicator has also been converted to a 0-100 scale.

[2] **A6*. Do your IT systems for managing orders link automatically with any of the following IT systems?**

(Multiple choice)	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)	❑	❑

Online purchasing

This question is in principal a question of the percentage of the total purchase that has been bought on the Internet respectively from the EDI channel. The calculated percent is then converted to a 0-100 indicator[3].

Online sales

This question is in principal a question of the percentage of the total sales that have been sold on the Internet respectively via the EDI channel. The calculated percentage is then converted to a 0-100 scale[4].

Human capital

A general finding in impact studies is that the education and other staff qualities are very important for the uptake of ICT. The human capital is thus important to capture.

The method to calculate the human capital indicator that has been used in this study is very much a market oriented one. The working population has been split into many subgroups according to four different characteristics. For each of the subgroups we calculated the average incomes from both the employed and the self-employed.

If the labour market functions well, the average income for each subgroup is the market's valuation of the different categories as labour inputs. This is in accordance with a long tradition represented by Jorgensen (1987) and Bureau of Labour Statistics (1993) both of which have somewhat different approaches for the US labour market. This has been further developed in US and Canadian data by Gu and Maynard (2001). The income means are then treated as the market valuation of different categories of labour in respective workplaces. In most workplaces there are of course only a small number of these categories represented. But with the help of the average income or prices on the labour input for each group it is possible to calculate a synthetic labour cost, or labour composition indicator for the whole workplace. This is a measurement that gives the labour quality, as the market values it, for each firm.

3 *This is too large to be in a footnote so it is placed at the end of the paper*

4

Survey Questions

2002 actually the situation year 2001	*13+20 Gives max 100 points*
2003 actually the situation year 2002	*17+26a Gives max 100 points*
2004 actually the situation year 2003	*12+26 Gives max 100 points*
2005 actually the situation year 2004	*15b+28 Gives max 100 points*
2006 actually the situation year 2005	*15b+29b Gives max 100 points*

The characteristics that have been used are the traditional ones: age, education and ethnicity. However, gender is not included. The choice of the different categories for each variable is based on how they are valued on the market. The education variable is split into two dimensions: orientation and levels. There are five different levels but only two fields: 1) the technical and natural science orientation and 2) all other orientations together. The levels starts with primary (level 1 and 2) and lower secondary, and ends with post graduate education (level 6). Concerning age, the workforce is split in as many as six categories, but of these the first and the sixth are very infrequent on the Swedish labour market. These categories are namely those who are 16-20 years of age, and those who have reached the age of 67 or more. The ethnicity variable is based on the countries where they were born. Those with an origin outside of Sweden are divided in four groups.[5]. For the observation for the year 2005 a slightly different measurement has been constructed that takes account of the differences in regions and industries to avoid the influence of different wage levels for the same qualifications between these.

What comes first: ICT use or broadband?

Internet is more important today than it was a few years ago. Today almost all companies in Sweden use the Internet in their business every day. Generally the ICT use of a firm is dependent on the standard of its ICT hardware and software. A crucial part of this standard is the capacity of its Internet connection. The insight of the importance of this has led to policy measures to enhance the development of broadband network. This is also the case in Sweden. This makes it meaningful to analyse the relation between broadband and ICT use.

[5] *The reason why the gender variable is excluded is because the human capital indicator that is used in this context was constructed for growth accounting purposes. Most of the differences of yearly earnings between men and women are more of an indicator of the differences of working hours than of anything else. In Sweden there are many more women than men who are working shorter hours. Since the quantitative labour input is measured in hours, the sector difference is already incorporated in that variable, and if the gender is included it is measured twice. The rest of the differences between the two sexes are considered to be a reflection of discrimination and not a difference in labour quality. Regional differences in wage levels also exist on the Swedish labour market, but these differences are not mainly due to differences in competence but rather to the size and character of the local labour market. The same is true for industries. In general there could be a tendency for an expanding sector to pay more for the same skill since it needs to attract more people. Sector differences can also be a reflection of regional differences. However, this is not only due to chance but also to conscious choices. Industries that are maturing are driven out from growth areas due to high wages and high rents. These factors are the reason for not including regions and sectors among our variables.*

The first question that will be addressed is: Has broadband access had any impact on the ICT use of a firm, or is it just the other way around, that ICT use determines if a firm decides to get broadband or not?

Many micro-studies on the firm level have been made concerning innovation and how it affects productivity, but not so many concerning different levels of Internet use and the frequency of broadband. One major example is the ICT impact study already mentioned, other important studies have been made by OECD and ONS and a Swedish one is a study by Hagén et al. (2007), on how Internet use affects innovation and therefore also productivity. However, here the focus is not on that effect, but instead on *how the use of Internet and the acquirers of broadband affect each other. This will be followed up by the analysis of the impact of broadband on productivity.*

The answer to the question of what comes first, if it is the firm's ICT use that makes it acquire faster Internet connection (broadband) or if it the access to (fast) broadband that allows companies to use Internet more widely, is probably that it is a combination of both, still it is of interest to get some quantitative indications of which direction is the stronger one.

The questions that will be discussed are thus:

- What kind of company acquires/has broadband?
- Is it a high level of ICT use that makes a company acquire/have broadband?
- Is it the access to broadband that increases the firm's ICT use?

The survey from 2001-2005 includes all large companies (over 250 employees) in Sweden and a sample of the smaller ones, 10-250 employees. Every year one-third of the smaller companies were replaced in the sample. So over time most of the large companies are represented, but only a small portion of the smaller companies.

Variables from the survey that is used in this analysis:

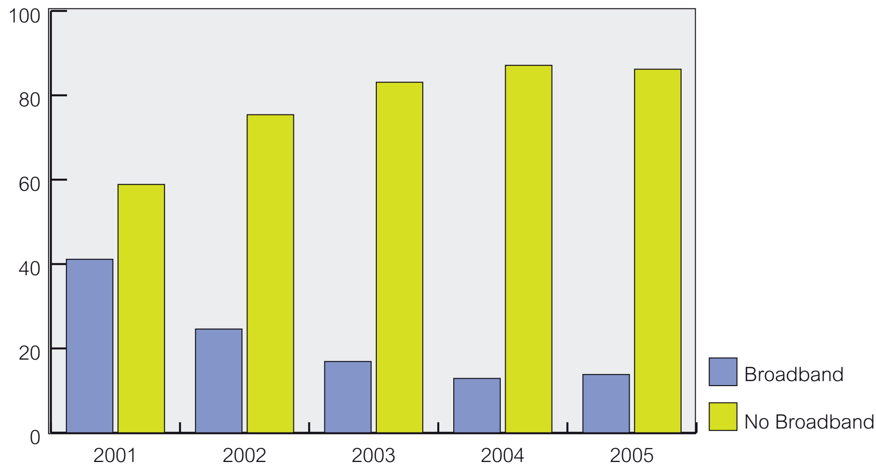
Intranet	If the companies have Intranet, 0/1 dummy
Extranet	If the companies have Extranet, 0/1 dummy
LAN	If the companies have Local Area Network, 0/1 dummy
WLAN	If the companies have Wireless Local Area Network, 0/1 dummy
PersInt	Share of employees with Internet connection

Calculated variables from the survey*:*

Speed	If the company has broadband (1) or not(0), dummy 0/1
ITLevel	The level of ICT use

Another problem of the database is that the questions in the survey were not the same for all years. From the survey, information about the company's different Internet connections was available. However, this analysis was limited to whether the firm had access to broadband or not. Therefore an indicator variable was created, speed, that takes the value of 1 if the company has access to broadband and 0 if it do not have broadband, irrespectively if it also has other types of Internet connections. The percentage of how many companies that have broadband for different years is presented in figure 1.

Figure 1. The percentage of companies in the survey that have broadband (1) and those that do not have broadband (0) respectively year



After removing some outliers a data set was constructed that consists of data from the surveys and from matching register data. The total data set consists of approximately 3000 companies for each year of which 595 are represented every year. Over a two-year period the data set consists of approximately 1900 companies.

Analyses of the relation between broadband and ICT use

The equation is of the type:

1. $\log [\rho/(1-\rho)] = \alpha + \beta x$

Here ρ is the probability that the dependent variable, speed, takes the value 1, α is the intercept and ε the error term.

x is a matrix of different variables that might affect the dependent variable: dummies for type of industry, if the company is multinational, if it is a small, medium or large company, a measure of the quality of the staff and if the companies have intranet, extranet, LAN or WLAN, the percentage of employees with access to Internet, and a measurement of the productivity (GPMFP, logarithm of gross production multifactor productivity). This equation will also be used in analyses of the chain; broadband – ICT use – productivity as the selection equation.

What comes first, the Internet use or the broadband connection?

Equation 2 is the one with ITLevel as the dependent (endogenous) variable and the Internet connection variable (speed) as explanatory. Because the endogenous variable can be expected to depend on a number of other variables, this has to be taken into account. Thus dummy variables that were included in the model were variables that indicated if the company was a part of a multinational business group and which industry it belonged to. When including these variables it is allowed for the possibility that different industries have different business cycles and different levels of usage of for example the Internet. The size of the company probably also affects their Internet use and therefore this was also taken into account.

The explanatory variable speed and the dependent variable ITLevel correlate and the effect might go in both directions. Because of this, the explanatory variable is considered to be endogenous, it is not entirely explained outside the model, and a 2SLS is therefore used to estimate the relationship. But if a lagged variable is used for speed, that is speed for one year earlier, it is no longer an endogenous variable and an ordinary multiple regression can be used. The equation is the same for these two methods, but the estimations are made differently.

The second alternative is constructed in the same way but here speed is the dependent variable and ITLevel the explanatory one (although it is also endogenous in one of the cases by the same criteria as speed above). These equations will be estimated with logistic regression.

The two equations:

2. $Y = \alpha_0 + \beta_0 z + \beta_1 x + \varepsilon_1$

(ITLevel= intercept + β_0Speed + $\beta_1$other variables + error term)

3. $\log[\rho/(1-\rho)] = \alpha_1 + \beta_2 y + \beta_3 x_2$

(log odds ratio for speed = intercept + β_2 ITLevel+ $\beta_3$other variables + error term)

Here Y is IT level, ρ is the probability that the variable speed will be 1, α is the intercepts and ε the error terms, and x is the same matrix as for equation 1 above.

Equation 1. In this equation, the selection equation, the variables that could explain the decision to acquire broadband are estimated. The dependent variable, delta-speed, is an indicator variable that takes the value 1 if the firm has changed to broadband and 0 if it did not change. In this test the dataset was restricted to consist of only the companies that did not have broadband at the beginning of the time-period. Thus it is possible to compare the companies that have just acquired broadband with the companies that still do not posses broadband.

This equation was also used to study what kind of variables that are typical for companies that already have broadband, independent of how long they have had it. The dependent variable is the indicator variable, speed. The companies that have had broadband one year were compared with those who didn't. This dataset was much larger.

This test was done with two different measures of staff quality, one with the percent of the employees that had a university degree of at least three years and one with the overall labour quality indicator. Labour quality gave more significant results and that became the preferred one. One reason that Labour quality gave better results could be that it takes more factors into account. The reason why the university degree variable was also tried was because the labour quality can be expected to have both an increasing and decreasing effect on the response variable. One part of this indicator that could possibly give a decreasing effect is that increased experience which improves the quality is strongly correlated with age, and it is more likely that younger people use Internet more and have more knowledge about this phenomena. In these equations a logistic regression was used in order to estimate the different variables' impact on broadband. The following result was obtained, see table 1.

Table 1. Access of Broadband

Dependent variable: speed02

Firms 2001-2002	Coefficient	
Under 10 2002	-0.24	
Over 250 2002	1.85	a
Labour Quality 2002	0.001	
Intranet 2002	0.65	a
Extranet 2002	0.19	
LAN 2002	0.89	a
WLAN 2002	1.05	a
Pers Int 2002	0.02	a

a Significant at 1%
b Significant at 5%
c Significant at 10%

As can be seen in table 1, large companies are typically companies that have broadband. The reason why the dummy variable for small companies did not become significant could perhaps be influenced by the fact that there were not so many observations in that group, even if the total number of observations is more important.

It is also of interest to compare the companies that acquire broadband with those that do not have broadband at all, and so a dataset was constructed that only contained the firms that did not have broadband the first year. This resulted in a much smaller dataset so it was much more difficult to draw conclusions from the estimate, especially for later years, since the number of firms that acquired broadband decreased rapidly. In these equations a logistic regression was used to estimate the variables impact on broadband. The following result was obtained for the years 2001 and 2002.

Table 2. Acquisition of Broadband

Dependent variable: delta-speed 2001-02

Firms 2001-2002	Coefficient	
Under 10 2001	0.36	
Over 250 2001	1.89	a
Labour quality 2001	0.001	c
Intranet 2001	0.79	a
Extranet 2001	0.03	

a Significant at 1%
b Significant at 5%
c Significant at 10 %

The result indicates that large companies were also more inclined to obtain broadband compared to medium sized companies. Possession of intranet was quite significant while the staff quality was less significant.

What comes first?

The levels

Although some variables have a significant effect on the dependent variable, most interest was concentrated on the question if ITLevel and Speed affects each other and if they did, in what direction and magnitude they affected each other. Equation 2 is a simple multiple regression and the results for the variable Speed is listed in table 3. The variable Speed seems to have a strong significant effect on the company’s ITLevel the following year for all these years. The independent variables from equation 1 were also included in this regression as control variables.

Table 3. The effect on ITLevel of broadband

Equation 2: Dependent variable ITLevel(One year later)

	Coefficient	
Speed 2001	4.57	a
Speed 2002	2.91	a
Speed 2003	2.99	a
Speed 2004	3.39	a

a Significant at 1%
b Significant at 5%
c Significant at 10 %

The result from equation 3, for all years, is presented in table 4. It is difficult to compare these results with the results presented earlier since in this case a logistic regression model was used. However, the level of significance is a good indicator. As can be seen from the table, even if a significant positive effect exists for some years, the results are not as strong as those in table 3.

Table 4. The effect on Broadband of the IT level

Equation 3: Dependent variable Speed level (lagged one year)

	Coefficient	
ITLevel 2001	0.02	c
ITLevel 2002	0.03	a
ITLevel 2003	0.01	
ITLevel 2004	0.05	a

a Significant at 1%
b Significant at 5%
c Significant at 10 %

The rest of the independent variables from equation 1 were also include in this regression

The change between the years

An effort was also made to explain the changes in ITLevel between the years 2004-2005, by using the variable dspeed05 (= 1 if the company acquired broadband between the years 2004-2005) and other variables **x**, already presented, from the “start” year (2004) when no company had broadband.

Example of the equation that was used to provide the result listed in table 5:

$$Delta\text{-}ITLevel0405 = dspeed05 + x04 + \varepsilon$$

In Table 5 the results from the estimation of how the ITLevel was affected by the firms not acquiring broadband is displayed. As we can see in table 5 the strongest result is for the first year.

Table 5. Effect on the change in ICT use of acquiring Broadband:

Equation 2:

Dependent variable Delta-ITLevel

	Coefficient	
DSpeed 2002	3.94	a
DSpeed 2003	2.65	
DSpeed 2004	2.29	b
Speed 2005	4.86	b

a Significant at 1%
b Significant at 5%
c Significant

It was also tested if the ITLevel affects the probability for a firm to acquire broadband, an example of the equation listed in table 6*: delta-speed0405 = ITLevel04 + x04 +* ε

That means that the changes in the variable speed (here if the company acquired broadband) between the years 2004-2005, is explained by using the variable ITlevel04 and other variables **x** from the "start" year, 2004, when none of these firms had broadband.

Table 6. The effect on probability of acquiring Broadband or the ICT use

Equation 3: Dependent variable Delta-speed

	Coefficient	
ITLevel 2001	0.03	b
ITLevel 2002	-0.01	
ITLevel 2003	0.01	
ITLevel 2004	0.01	

a Significant at 1%
b Significant at 5%
c Significant at 10 %

The result is not nearly as strong as in the earlier equation and the only significant result is for the years 2001/2002.

ICT use influences broadband, but broadband influences ICT use more

In 2005 almost 90 percent of the firms in the survey had broadband and even more have it today. Although most companies in Sweden already have broadband, it is still of interest to see which variables affected the company's decision to acquire it, since the speed of Internet connection is increasing. In addition, the same factors that influenced the decision to acquire broadband will probably be the factors that could explain which firms which will lead the chase towards faster and faster speed. It is thus also of interest to see what characterises a company with broadband and the effect of higher speed on the ICT use.

The analyses give the expected result that it is large companies that lead the way to the broadband society. There are also differences between industries and the decision to get broadband is more probable if the firm is part of a multinational group. There are also differences among industries. However, the differences among industries are not of any particular interest in this context; these variables were included in the equations only to control for these differences.

The analyses also confirm the hypothesis that the influences between broadband and ICT use go both ways. But since speed has a significant effect on ITLevel every year, it is obvious that firms with a high ITLevel most likely have a fast Internet connection. This means that if a company increases its Internet connection and get broadband it is most likely to increase its Internet use more than if they did not acquire broadband. The arrow that points in the other direction is not as strong. This means that if the company already has a high usage of Internet, it will increase its probability to get broadband, but not with the same force as in the other direction.

It was also tested if the ITLevel affected the decision to acquire broadband and if the acquiring of broadband caused a high increase in the IT level. But the data material was quite small for analysis over time, and therefore the result of these exercises could not be expected to lead to so many significant results. Still it could be seen that the acquiring of broadband had a stronger impact on the changes in ITLevel than the contrary. This gives a further indication of which is the main direction. *It is more likely that broadband "comes first", and then the variable ICT use follows. This is also what could be expected. However, it should be noted that it is still not a one way street.*

Broadband – ICT use – Productivity

Since it seems that the broadband access tends to increase ICT use, measured as IT level, it will be meaningful to analyse the whole chain: broadband – ICT use – productivity. At first the 2SLS procedure was used, where speed was an endogenous variable, but this gave no significant results. However, it could be expected that it takes time, at least one year, before any results from the broadband investment could show in the ICT use as the results already presented indicate. So some explanatory variables were lagged, which in this case means that the speed from the previous year was used. But it is necessary to take into account that some of the exogenous variables are most likely to have effect the same year, so some variables were from the same year as the dependent one. In all equations the firms had been controlled for industry and if the firms belonged to a multinational firm or not. The dataset that was used consists of companies that are represented in a time period of two years. The data stretches from the year 2001 to 2005, and so it was possible to make four year-pairs; 01/02, 02/03, 03/04 and 04/05.

The model had three equations in which this relationship is studied.

1. The first, the broadband equation explains what kind of firms decide to acquire/ have broadband.
2. The *ICT equation*, explained what kind of variables that linked broadband and the ICT use, measured as the IT level.
3. In the third equation the productivity variable is used as a response or dependant variable, and ITLevel as an explanatory variable.

To estimate the equation 3SLS (Three stage least square) was used that could deal with the problems in the dataset in an effective way, for example correlated error terms.

The estimation gave a significant positive relationship between broadband and productivity. The relationship depends on which industry the company is part of, the size of the company, and if the company is part of a multinational group or not.

As already mentioned, several studies have dealt with the relationship between innovation activities and productivity in Sweden and other European countries, see for example: Lööf & Heshmati (2006), Griffith, R., Huergo, E., Mairesse, J. & Peters, B. (2006) and Hagén et al. (2007). In this case the focus will instead be on the connection between broadband and productivity, in order to find out if broadband affects the company's productivity.

There are many possible ways to measure productivity. The most common is value added labour productivity. An alternative is the gross production labour productivity. This means that it is roughly total sales, instead of the value added, that is divided by the employment. In the third alternative the input of capital is also taken into account and not only the input of labour. This alternative is called value added multifactor productivity. Finally the gross production multifactor productivity is also used as productivity measurement. This multifactor concept is a measure where the input of intermediates, labour and capital is taken into account and all these inputs are set in relation to the total sales or in other words, gross production.

In order to be able to follow some variables over time the surveys from different years were combined. This means that the datasets had to be restricted to the firms that had answered the questions for at least two consecutive years.

Speed1 = Companies that had broadband from the beginning of the period.

Speed0 = Companies that did not have broadband, (and did not acquire broadband during the two-year period).

Dspeed = Companies that acquired broadband between the first and the second year.

The relationship between innovation and productivity has been an increasing part of the microanalyses for some time now. In 1979 Grichlies was one of the first trying to find the link between innovation and productivity. In 1998 Crepon, Duguet and Mairesse (CDM) developed Grichlies' model in an attempt to better capture the link between productivity, innovation and research in manufacturing companies in France. They introduced some new features in their innovation analysis. Their model included four equations between productivity, innovation input and innovation output;

a) $g_i = x_{0i}b_0 + u_{0i}$ Selection

b) $k_i = x_{1i}b_1 + u_{1i}$ Innovation input

c) $t_i = \alpha_K k_i + x_{2i}b_2 + u_{2i}$ Innovation output

d) $q_i = \alpha_I t_i + x_{3i}b_3 + u_{3i}$ Productivity

The first equation is a selection equation that determines if the company is engaged in research activities where g_i is a latent (unobservable) dependent variable. The firm makes the decision to invest in research if this variable is larger than some constant threshold value. The second equation shows the size of the research activities at the company, where k_i is the research capital per employee. Equation c is an innovation equation where t_i shows the share of innovative sales. The innovation output is measured here by the number of patents. Their last equation is a productivity equation and it explains how much the innovation affects the productivity and the variable q_i is the logarithm of labour productivity.

Here the focus lies on the process of acquiring broadband. It is a process that according to our hypothesis affects the company's productivity. This model is close to that used by Crepon et al since the question and data are quite similar. A relationship between broadband and productivity is estimated in an equation-system with three equations. The number of equations is due to the fact that there is no parallel to the innovation input equation, which leads to the reduction to three equations. Since the objective is to study the difference between the companies that have broadband and those that do not, the full sample will be used in the entire analysis.

The first equation is a selection equation. In innovation studies this is used to analyse which factors influence the decision to innovate, and in this case to acquire/have broadband. The broadband-speed is the response. Since the response variable is a 0/1 variable a logistic regression was used to estimate this model.

Equations 1, the selection equation;

$$Log\ (p/\ (1-p)) = \alpha + \sum_i \beta_i x_i$$

Here ρ is the probability for the response variable to assume the value 1 and $x$are all the explanatory variables, β the coefficient for each x.

This means that this equation is the same as equation 1 in the preceding part of this paper.

The main question in this part of the study is"Does broadband have any impact on firm productivity?" However, it is not probable that speed in itself has any direct influence on the company's productivity; it is more likely that it works via improving the condition for the Internet-use. Thus it is a model with two equations that is used: In equation 2 the ITLevel (a variable that tries to capture the ICT use of a firm) is used as response variable (h) with a broadband-indicator as explanatory variable. And finally in equation 3, parallel to equation d, productivity (t) is the response variable with ITLevel as an explanatory variable.

Equations 2 and 3:

$$h = \sum_i x_i \beta + \varepsilon_i$$

$$t = h + \sum_i z_i \beta + \varepsilon_i$$

The explanatory variables in equation 2 are as before beside a dummy for broadband; eleven dummies for which industry the company is part of, two dummies for the firm size, three dummies for the geographic market and also four dummies for different networks and labour quality.

t = Productivity, here measured as the logarithm of Gross Production Multi Factor Productivity, GPMFP.

The explanatory variables in the third equation are almost the same as in the second equation. The difference is that there were no dummy variables for networks; instead the ITLevel was used as an explanatory variable.

In the ordinary regression model all the explanatory variables must be exogenous (the explanatory variables must be explained outside the model, the response variable are not allowed to have any influence on the explanatory variables), but in some of the estimations ITLevel and Broadband-speed most probably influenced each other. That is a violation of the OLS (Ordinary Least Square) assumption.

In this case it was a problem with an endogenous variable (the variable is caused by the response-variable) in the model. Therefore an estimation method was used that could deal with this problem of endogenous variables. Another problem was that equations 2 and 3 came from the same dataset and it is therefore likely that the error terms in equation 2 and 3 are correlated.

The advantage of broadband

The first equation, equation 1, tests which variables that influence the decision to acquire broadband. This means as already mentioned that the equation is identical to the first equation, the selection equation, in the preceding part of the paper.

In some of the estimations all Internet variables were used from a year earlier than the productivity variable, in other words they were lagged. In equation two, speed was the main endogenous variable and therefore it had to be replaced with an estimate based of instrument-variables.

Table 7. The relation between broadband and other factors on ITLevel 2002

Equation 2 – Dependent variable ITLevel 2002		
Under10 2002	-3.00	c
Over250 2002	1.30	
Labour Quality 2002	-0.01	a
Intranet 2002	2.85	a
Extranet 2002	6.56	a
LAN 2002	4.03	a
WLAN 2002	5.55	a
PersInt 2002	0.06	a
Speed 2001	4.51	a

The result was difficult to interpret, probably because the instruments that were used to explain the endogenous variable ITLevel were a linear combination of the other variables in the model. To avoid that problem the variable lagged Speed was used, (the lagged variable is not endogenous). These results were much easier to interpret. It is actually likely that it takes some time before the effect of getting broadband influences the use of ICT, so it is even better to use the variable speed from previous year. This means that data from a three-year period were used in the estimation. Due to the short time span in the dataset it was only possible to get three different estimates.

In equation 2 with ITLevel as a dependent variable many variables became significant. It is not a very surprising result that some Internet variables can explain a part of the IT level. Of more interest is that it seems that speed has a strong impact on IT level. It has a large high coefficient which is highly significant. One surprising result is that labour quality has a negative impact on ITLevel. However, as has already been mentioned, labour quality contains, among others, one variable, age, which can have a decreasing effect on ITLevel. From table 8 follows that for the two following years Speed is also highly significant and positive.

Table 8. The effect of broadband on ITLevel

Dependent variable	Independent variable	Coefficient	
ITLevel2003	Speed2002	2.7	a
ITLevel2004	Speed2003	3.0	a

IT use affects productivity

The productivity median was a little higher every year from 2001 till 2003 for companies that acquired broadband between 2001 and 2002 (speed02=1) than those that did not acquire broadband during that period.

Table 9. The relation between productivity and ITLevel

Equation 3 – Dependent variable GPMFP03

	Coefficient	
Under 10 2003	0.04	b
Over 250 2003	-0.01	
Labour Quality 03	0.0002	a
ITLevel 2002	0.0024	b

In the next equation, equation 3, with productivity as dependent variable, three variables become significant. Most important is the fact that the ITLevel had a significant positive impact on productivity. From table 10 follows that this is also true for 2004 but not for 2003.

Table 10. The relationship between IT use and productivity

Independent variable	Dependent variable	Coefficient	
ITLevel 2003	GPMFP2004	-0.01	b
ITLevel 2004	GPMFP2005	0.01	c

Acquisition of broadband

In order to study the difference in productivity among the companies that acquired broadband and those who did not, the dataset must be restricted to only include firms that started the period without broadband. The ITLevel was higher for the companies that acquired broadband both before they acquired broadband and after. A test was also performed to study if there were any direct links between acquiring broadband and change in productivity. In parallel with what was found earlier, these did not exist for the same year. However, those that acquired broadband between 2001 and 2002 increased their productivity between year 2001 and 2003, as can be seen in table 12. After that the number of observations was too few to produce any significant results.

Table 12. The relationship between broadband and other variables and the change in productivity 2001-2003

Dependent variable: Change in productivity 2001-03		
	Coefficient	R^2 = 0.35
Speed 02	0.09	b
Under 10 2001	0.11	
Over 250 2001	-0.05	
Labour quality 2001	0.0001	
Intranet 2001	0.05	
Extranet 2001	0.07	

Conclusions

Nowadays most of the companies in Sweden have broadband, but only five to ten years ago this was not the case. The firms that are inclined to acquire respectively have acquired broadband were primarily larger companies.

The estimations have shown that in most cases there seems to be a positive relationship between broadband and productivity.

Broadband gave a significant impact on the ICT use in every dataset. Some other IT variables also showed a positive impact on the ICT use like for example intranet or extranet systems.

For most of the years the ICT use (ITLevel) had a positive significant impact on productivity.

Getting broadband gave a boost to firm productivity for the years 2001-2002. The datasets that were used in these tests got smaller and smaller every year which could explain why there were no significant results for later years.

Generally it was found that broadband had a positive impact on ITLevel in all the tests and ITLevel has a positive impact on the productivity in most cases, speed apparently seems to have a positive effect on productivity. So the conclusion is that broadband and productivity seem to link together in a positive way. *If the company has broadband it is more likely that it will have higher productivity.*

Does ICT use improve productivity?

Broadband is not the only trigger to more intense ICT use, a lot of other factors influence the ICT use of a firm. It is thus of interest to go beyond the broadband problematic and study the ICT use as such and its possible explanatory power of firm productivity.

However, as mentioned before there is an ongoing discussion of if it is good firms that do everything right, both what can be and is measured and what is not, because they have a good management or if it is firms' recordable actions that create their good performance. That is, if it is the good companies that use ICT extensively or if it is heavy ICT users that performs well. A first simple test which could shed some light on the controversy, is a calculation of the simple correlation-matrix with productivity and ICT use for different years, see table 13. The indicator of past performance that is chosen is the gross production multifactor productivity (GPMFP) and as indictor of the ICT use is the ITLevel. The productive firms have of course more resources to invest in different assets that they expect will improve their performance. Some of these will give a boost to their future productivity and some will fail. If ICT is part of these investments, and if they also use these investment intensively, which hopefully is captured by the composite indicator ITLevel, there should be significant correlations between the GPMFP measurement and the ITLevel for the following years. This means that the cells above the diagonal line, from the upper left corner to the right lower corner, should contain mostly positive and significant correlations. However as can be seen from the table, not even half of them fulfil these criteria. Only 12 of 25 combinations are positive and significant, and of these just three are significant on the 1 percent level. Still there are just two negative coefficients and they are very far from becoming significant, so the overall tendency is quite clear: the productive firms use ICT more than others.

If a relationship between the ICT use and the productivity the same year exists, then this means that the influence can equally well go in both directions. These coefficients are all but one significant and, and all four significant coefficients are on the 1 percent level or even stronger. Finally when the ICT use a certain year is correlated with the productivity the following years, the general picture becomes very clear. Of these 10 combinations the coefficients are all but one positive and significant and that at least at the 1 percent level. So even if there are clear indications that productive firms use ICT more intensively, the indications that the firms that use ICT more heavily are inclined to be productive in the future is that much stronger.

Table 13. The relation between GPMFP and ITLevel for different years

	ITLevel01	ITLevel02	ITLevel03	ITLevel04	ITLevel05
GPMFP98	0.02585	0.05303	0.05288	0.05819	0.05201
	0.3071	0.0319	0.0350	0.0247	0.0478
GPMFP99	0.07749	0.02603	-0.01364	-0.00135	0.02395
	0.0016	0.2764	0.5748	0.9572	0.3488
GPMFP00	0.04253	0.00544	0.01490	0.01482	0.01517
	0.0305	0.7828	0.4586	0.4767	0.4734
GPMFP01	-0.00295	0.06352	0.05441	0.06193	0.01381
	0.8782	0.0009	0.0054	0.0023	0.5033
GPMFP02	0.06730	0.04629	0.02806	0.02930	0.00481
	0.0006	0.0146	0.1449	0.1425	0.8123
GPMFP03	0.09699	0.07573	0.07075	0.06069	0.04724
	<.0001	<.0001	0.0002	0.0020	0.0177
GPMFP04	0.02251	0.07697	0.05555	0.07772	0.04824
	0.2733	<.0001	0.0037	<.0001	0.0142
GPMFP05	0.09242	0.17410	0.16460	0.18944	0.16846
	<.0001	<.0001	<.0001	<.0001	<.0001

Green marks *correlations that are significant on at least 1 percent Level*
Blue marks *correlations that are significant on at least 5 percent Level*

However this is all based on simple correlations, which were not very large, and many other factors could be influencing these relationships. In order to get more definitive answers to our hypotheses it is necessary to move on to regression analysis so more factors could be taken into account at the same time.

For this a panel data has been created with economic and staff data for the years 1998-2005 and ICT use data for the years 2001-2005. The dependent variable will as before be the natural logarithm of the gross production multifactor productivity, GPMFP. Besides the lagged GPMFP, the ITLevel and Labour quality are the explanatory variables, also the differences that are due to the industry, if the firm is part of international group and the years is taken into account of. A simple OLS regression gives the following result, see table 14.

Table 14. Productivity explained in an OLS regression

Adj R-squared = 0.62

Dependant variable: GPMFP

	Coef.	P>t
GPMFP		
t-1.	1.010	0.000
Labour quality		
t	.00012	0.029
t-1.	-.00006	0.365
IT Level		
t-1.	.0025	0.001
t-2.	.0007	0.211

The results indicate that even if the effect of productive firms using ICT has more been taken into account by including the lagged productivity; there is still a positive effect of a higher ICT use. Since it takes some time for an increased ICT use to affect the efficiency of the firm, as already have been proved, an indicator of the ICT use one and two years before has been included. However, even if the coefficient for ITLevel lagged two years is positive, it is not at all significant. This could perhaps be interpreted as if the ICT revolution moves so fast that it is just last year's use that really affects this year's performance.

However, the simple OLS regression is based on very strict restrictions which are not fulfilled in a panel data set, since by construction the unobserved panel-level effects are correlated with the lagged dependent variables, making standard estimators inconsistent. Thus a GMM regression has been used instead, more specifically a linear dynamic panel-data model that include lags of the dependent variable as covariates and contain unobserved panel-level effects. This fits a dynamic panel-data model and uses the Arellano-Bover/Blundell-Bond (1995, 1998) estimator.

$$y_{it} = \sum_{j=1}^{p} \alpha_j y_{i,t-j} + x_{it}\beta_t + w_{it}\beta_2 + \upsilon_i + \varepsilon_{it}$$

where

The α_1.................α_ρ are ρ parameters to be estimated

x_{it} is a l xk_1 of strictly exogenous covariates

β_1 is a k_1 x1 vector of parameters to be estimated

w_{it} is a 1xk_2 vector of predetermined covariates

β_2 is a k_2x1 vector of parameters to be estimated

v_i are the panel-level effects (which may be correlated with w_{it} or with x_{it}

ε_{it} are i.i.d. or come from a low-order moving-average process , with variance σ_ε^2

x and *w* may contain lagged independent variables and time-dummies

The GMM estimator of Arellano-Bover/Blundell-Bond that uses differences as instrument variables solves some of these problems. The robust version which is used here is robust to heteroscedasticity in the errors. Since the two-step VCE version is known to be severely biased, the Windmeijer bias–corrected estimator for robust VCE two-step GMM estimators is used instead.

Table 15. The relationship between productivity and ICT use

Two-step results		
WC-Robust		
GPMFP	Coef.	P>z
$GPMFP_{t-1}$	1.03	0.000
Labour quality		
t	-.0020	0.000
t-1.	-.0036	0.001
t-2.	.0053	0.000
ITLevel		
t-1.	.010	0.000
t-2.	.006	0.000

Instruments for differenced equation[6]

As can be seen in table 15 the ICT use of a firm the year before and two years before has quite a significant effect on the productivity measured as the gross production multifactor productivity. This is true when taken into account the industry the firm belongs to, if it is part of a multinational firm or if it has more than 250 employees as well as the staff quality. The last mentioned variable seems to be quite significant but its total effect is in principle zero. The main explanation to this is of course that the lagged productivity is included among the independent variables. First its effect is negative, but this balances after a couple of years with a positive effect of equal magnitude. It is probably true that it takes some time before an upgrading of the staff before the full benefit is reached, which is reflected in this pattern. If the lag structures change, the variable ITLevel still comes out significant and its total effect over the years is positive.

Finally a test of different productivity specifications has been performed. Besides the traditional measurement value added labour productivity and gross production multifactor productivity, two measurements that are rather close to those have also been used: gross production labour productivity and value added multifactor productivity. All these are defined earlier.

[6] *GMM-type: L(2/.).GPMFP L(2/.).L.GPMFP L(2/.).L2.GPMFP L(2/.).L.Labourquality L(2/.).L2. Labourquality L(2/.).L.ITlevel*
L(2/.).L2.ITlevel

Instruments for level equation
Standard instrument variables: Ind1 Ind2 Ind3 Ind4 Ind5 Ind6 Ind7 Ind8 Ind9 Ind11 MultiUSA MultiOvr MultiSwe Large_firms Year2004

Table 16. Different productivity measurements compared

	VALP		GPLP		VAMFP		GPMFP	
	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z
Productivity								
t-1	.69	0.000	.89	0.000	.75	0.000	1.03	0.000
Labourquality								
t	-.0056	0.000	-.0056	0.000	-.008	0.000	-.0020	0.000
t-1.	.0014	0.649	.0016	0.298	-.009	0.020	-.0036	0.001
t-2.	.0050	0.090	.0041	0.009	.018	0.004	.0053	0.000
ITLevel								
t-1.	.040	0.000	.036	0.000	.047	0.000	.010	0.000
t-2.	-.004	0.000	-.002	0.027	.0002	0.903	.007	0.000

The main result of this test is the stability of the estimation in all the productivity specifications. The large majority of the productive firms are also productive the next year. Labour quality is over the years neutral, but starts out negatively. This could be interpreted that take time before new qualified staff is fully productive. But most important the ICT use gives a boost to the productivity regardless of how it is measured. In the measurement there the input of intermediates is not taken account of, the full effect seems to disappear already after two years, while it lingers another year in the multifactor specifications when also this input is included in the input specification.

The conclusion is ICT use improves firm productivity.

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Appendix 1.
An overview of the question network purchase in the E-business surveys

Survey	Question number	Question: Have the firm bought anything on the Internet/ EDI other networks					
2002 actually the situation year 2001	7	Have you bought on the Internet/EDI	Have you bought more than 1%				
		Yes is interpreted as 0.5	2=Yes Interpreted as 1.5				7 gives max 1 points
2003 actually the situation year 2002	8a+27a	Have you bought less than 1%	Have you bought more than 1%				
		1=Yes Interpreted as 0.5	2=Yes Interpreted as 1.5				8a+27a gives max 3 points
2004 actually the situation year 2003	8a+27a	Have you bought less than 1%	Have you bought more than 1-9%/ More than 1%	Have you bought more than 10-24%	Have you bought 25% or more		
		1= Yes Interpreted as 0.5	2=Yes Interpreted as 2.5 respectively 1.5	3=Yes Interpreted as 5	4= Yes Interpreted as 16	5= Yes Interpreted as 25	8 a+27a gives max 26.5 points

Survey	Question number	Question: Have the firm bought anything on the Internet/ EDI other networks					
2005 actually the situation year 2004	12b+29b	Have you bought less than 1%	Have you bought more than 1-4%/ More than 1%	Have you bought more than 5-9%	Have you bought more than 10-24%	Have you bought 25% or more	
		1= Yes Interpreted as 0.5	2=Yes Interpreted as 2.5 respectively 1.5	3= Yes Interpreted as 7	4= Yes Interpreted as 16	5= Yes Interpreted as 35	12b a+29b gives max 36.5 points
2006 actually the situation year 2005	14b+28b	Have you bought less than 1%	Have you bought more than 1-4%/ Have you bought 1-24%	Have you bought more than 5-9%/ Have you bought 25-49%	Have you bought more than 10-24%/ Have you bought 50-74%/	Have you bought 25% or more/ Have you bought 75% or more	
		1= Yes Interpreted as 0.5	2= Yes Interpreted as 2.5 for 14b/ 12 for 28b	2= Yes Interpreted as 7 for 14b / 37 for 28b	2= Yes Interpreted as 1 for 14b / 62 for 28b	2= Yes Interpreted as 35 for 14b/ 85 for 28b	12b a+29b gives max 100 points

Appendix 2. Estimation results

```
. xtdpd GPMFP L(1).GPMFP L(0/2).Labourquality L(1/2).ITLevel, dgmmiv(L(2/0).GPMFP L(2/1).Labourquality
L(2/1).ITLevel) liv(Year1998 Year1999 Year2000 Year2001 Year2002 Year2003 Year2004 Year2005 Medium_
seized_firms Large_firms Ind1 Ind2 Ind3 Ind4 Ind5 Ind6 Ind7 Ind8 Ind9 Ind11 Ind12 MultiUSA MultiOvr
MultiSwe Time) vce(robust) twostep noconstant
note: Year1998 dropped from liv() because of collinearity
note: Year1999 dropped from liv() because of collinearity
note: Year2000 dropped from liv() because of collinearity
note: Year2001 dropped from liv() because of collinearity
note: Year2002 dropped from liv() because of collinearity
note: Year2003 dropped from liv() because of collinearity
note: Year2005 dropped from liv() because of collinearity
note: Ind12 dropped from liv() because of collinearity

Dynamic panel-data estimation             Number of obs       =     4893
Group variable: PeOrgNr                   Number of groups    =     2693
Time variable: Time
Obs per group:    min =       1
avg =  1.816933
max =       3

Number of instruments =    40             Wald chi2(6)        =  59440.11
Prob > chi2          =    0.0000
Two-step results

WC-Robust
GPMFP      Coef.   Std. Err.     z    P>z     [95% Conf. Interval]

GPMFP
L1.    1.030095   .0515059    20.00   0.000     .9291453    1.131045
Labourqual~y
--.   -.0020281   .0000863   -23.49   0.000    -.0021973   -.0018589
L1.   -.0035758   .0011205    -3.19   0.001     -.005772   -.0013797
L2.    .0052718   .0011839     4.45   0.000     .0029513    .0075922
ITLevel
L1.    .0096443   .0025193     3.83   0.000     .0047065     .014582
L2.     .006525    .000695     9.39   0.000     .0051628    .0078872

Instruments for differenced equation
GMM-type: L(2/.).L2.GPMFP L(2/.).L.GPMFP L(2/.).GPMFP L(2/.).L2.Labourquality
L(2/.).L.Labourquality L(2/.).L2.ITLevel L(2/.).L.ITLevel
Instruments for level equation
Standard: Year2004 Medium_seized_firms Large_firms Ind1 Ind2 Ind3 Ind4 Ind5 Ind6 Ind7 Ind8
Ind9 Ind11 MultiUSA MultiOvr MultiSwe Time

. xtdpd GPLP L(1).GPLP L(0/2).Labourquality L(1/2).ITLevel, dgmmiv(L(2/0).GPLP L(2/1).Labourquality L(2/1).
ITLevel) liv(Year1998 Year1999 Year2000 Year2001 Year2002 Year2003 Year2004 Year2005 Medium_seized_
firms Large_firms Ind1 Ind2 Ind3 Ind4 Ind5 Ind6 Ind7 Ind8 Ind9 Ind11 Ind12 MultiUSA MultiOvr MultiSwe
Time) vce(robust) twostep noconstant
note: Year1998 dropped from liv() because of collinearity
note: Year1999 dropped from liv() because of collinearity
note: Year2000 dropped from liv() because of collinearity
note: Year2001 dropped from liv() because of collinearity
note: Year2002 dropped from liv() because of collinearity
note: Year2003 dropped from liv() because of collinearity
note: Year2005 dropped from liv() because of collinearity
note: Ind12 dropped from liv() because of collinearity
```

Dynamic panel-data estimation Number of obs = 5032
Group variable: PeOrgNr Number of groups = 2754
Time variable: Time
Obs per group: min = 1
avg = 1.82716
max = 3

Number of instruments = 40 Wald chi2(6) = 213053.27
Prob > chi2 = 0.0000
Two-step results

WC-Robust
GPLP Coef. Std. Err. z P>z [95% Conf. Interval]

GPLP
L1. .8942449 .0554944 16.11 0.000 .7854779 1.003012
Labourqual~y
--. -.0056395 .0001774 -31.80 0.000 -.0059871 -.0052919
L1. .0016225 .0015598 1.04 0.298 -.0014347 .0046797
L2. .0040613 .0015447 2.63 0.009 .0010338 .0070888
ITLevel
L1. .0364993 .0051971 7.02 0.000 .0263131 .0466855
L2. -.0016023 .0007255 -2.21 0.027 -.0030243 -.0001803

Instruments for differenced equation
GMM-type: L(2/.).L2.GPLP L(2/.).L.GPLP L(2/.).GPLP L(2/.).L2.Labourquality
L(2/.).L.Labourquality L(2/.).L2.ITLevel L(2/.).L.ITLevel
Instruments for level equation
Standard: Year2004 Medium_seized_firms Large_firms Ind1 Ind2 Ind3 Ind4 Ind5 Ind6 Ind7 Ind8
Ind9 Ind11 MultiUSA MultiOvr MultiSwe Time

. xtdpd VALP L(1).VALP L(0/2).Labourquality L(1/2).ITLevel, dgmmiv(L(2/0).VALP L(2/1).Labourquality L(2/1).ITLevel) liv(Year1998 Year1999 Year2000 Year2001 Year2002 Year2003 Year2004 Year2005 Medium_seized_firms Large_firms Ind1 Ind2 Ind3 Ind4 Ind5 Ind6 Ind7 Ind8 Ind9 Ind11 Ind12 MultiUSA MultiOvr MultiSwe Time) vce(robust) twostep noconstant
note: Year1998 dropped from liv() because of collinearity
note: Year1999 dropped from liv() because of collinearity
note: Year2000 dropped from liv() because of collinearity
note: Year2001 dropped from liv() because of collinearity
note: Year2002 dropped from liv() because of collinearity
note: Year2003 dropped from liv() because of collinearity
note: Year2005 dropped from liv() because of collinearity
note: Ind12 dropped from liv() because of collinearity

Dynamic panel-data estimation Number of obs = 4958
Group variable: PeOrgNr Number of groups = 2714
Time variable: Time
Obs per group: min = 1
avg = 1.826824
max = 3

Number of instruments = 40 Wald chi2(6) = 142245.55
Prob > chi2 = 0.0000
Two-step results

WC-Robust
VALP Coef. Std. Err. z P>z [95% Conf. Interval]

VALP
L1. .6907944 .0833085 8.29 0.000 .5275127 .8540761
Labourqual~y
--. -.0055677 .000177 -31.46 0.000 -.0059145 -.0052209
L1. .0013735 .003021 0.45 0.649 -.0045476 .0072946
L2. .0050182 .0029586 1.70 0.090 -.0007806 .010817
ITLevel
L1. .0395507 .0052497 7.53 0.000 .0292614 .04984
L2. -.003652 .0007655 -4.77 0.000 -.0051523 -.0021517

Instruments for differenced equation
GMM-type: L(2/.).L2.VALP L(2/.).L.VALP L(2/.).VALP L(2/.).L2.Labourquality
L(2/.).L.Labourquality L(2/.).L2.ITLevel L(2/.).L.ITLevel
Instruments for level equation
Standard: Year2004 Medium_seized_firms Large_firms Ind1 Ind2 Ind3 Ind4 Ind5 Ind6 Ind7 Ind8
Ind9 Ind11 MultiUSA MultiOvr MultiSwe Time

. xtdpd VAMFP L(1).VAMFP L(0/2).Labourquality L(1/2).ITLevel, dgmmiv(L(2/0).VAMFP L(2/1).Labourquality L(2/1).ITLevel) liv(Year1998 Year1999 Year2000 Year2001 Year2002 Year2003 Year2004 Year2005 Medium_seized_firms Large_firms Ind1 Ind2 Ind3 Ind4 Ind5 Ind6 Ind7 Ind8 Ind9 Ind11 Ind12 MultiUSA MultiOvr MultiSwe Time) vce(robust) twostep noconstant
note: Year1998 dropped from liv() because of collinearity
note: Year1999 dropped from liv() because of collinearity
note: Year2000 dropped from liv() because of collinearity
note: Year2001 dropped from liv() because of collinearity
note: Year2002 dropped from liv() because of collinearity
note: Year2003 dropped from liv() because of collinearity
note: Year2005 dropped from liv() because of collinearity
note: Ind12 dropped from liv() because of collinearity

Dynamic panel-data estimation Number of obs = 4885
Group variable: PeOrgNr Number of groups = 2675
Time variable: Time
Obs per group: min = 1
avg = 1.826168
max = 3

Number of instruments = 40 Wald chi2(6) = 20472.01
Prob > chi2 = 0.0000
Two-step results

WC-Robust
VAMFP Coef. Std. Err. z P>z [95% Conf. Interval]

VAMFP
L1. .7502645 .0928598 8.08 0.000 .5682626 .9322664
Labourqual~y
--. -.0084626 .0003325 -25.45 0.000 -.0091143 -.0078108
L1. -.0089154 .0038408 -2.32 0.020 -.0164433 -.0013875
L2. .0176102 .0039603 4.45 0.000 .0098482 .0253722
ITLevel
L1. .0469956 .009149 5.14 0.000 .0290637 .0649274
L2. .0002306 .0018868 0.12 0.903 -.0034674 .0039286

Instruments for differenced equation
GMM-type: L(2/.).L2.VAMFP L(2/.).L.VAMFP L(2/.).VAMFP L(2/.).L2.Labourquality
L(2/.).L.Labourquality L(2/.).L2.ITLevel L(2/.).L.ITLevel
Instruments for level equation
Standard: Year2004 Medium_seized_firms Large_firms Ind1 Ind2 Ind3 Ind4 Ind5 Ind6 Ind7 Ind8 Ind9 Ind11 MultiUSA MultiOvr MultiSwe Time.

Does ICT-use improve your career?

Effects from high ICT-use valued on the labour market*

Caroline Ahlstrand, Statistics Sweden

Abstract

Findings suggest that the digital divide to some extent existed on the Swedish labour market in 2000 and 2003. Individuals with less ICT-knowledge were left behind in the ICT evolution. Data from the Eurostat Community survey on ICT use by individuals was used and pooled with register data from the years 2000 and 2003. Proxies for the ICT-knowledge were created from the frequency of the Internet use and for different task preformed on the Internet. In the regression model individuals ICT-knowledge hade a positive effect on income. Individuals using the Internet daily and using e-mail had higher income in both 2000 and 2003. The same is true for using the Internet banking in 2003. The only negative ICT effect on income came from being part of a discussion group or using the Internet for "chatting". When taking income history into account, individuals with higher ICT-knowledge hade a higher income development years after the ICT-knowledge were measured. For the odds ratio of being employed findings suggested that individuals with lower ICT-knowledge were doing worse in the labour market. In 2000 findings suggest that individuals with frequent Internet use had lower odds of being unemployed. Three years later no effect on the odds of being unemployed could be found between different ICT-users.

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1. Background

Introduction

The proportion of more advanced jobs has increased substantially during the last two centuries. This has led to a decreasing demand in industrialized countries for those with a short education. During the last two decades another factor has become important in the struggle for survival and market shares; ICT (Information and communication technology). The efficiency gains for the businesses from using computers and later the Internet and the World Wide Web are enormous. Different activities like; E-mail, CAD (computer aided design), production systems, E–commerce have all had large impacts on productivity.

The ICT evolution has raised demand for, not only skilled workers, but skilled workers who know how to use a computer. As computers used to be relatively expensive and complicated to use a situation was crated that was called "the digital divide". The digital divide is defined by OECD (2001 a:8) as "the gap between individuals, households, business and geographic areas at different socio-economic levels with regard to both their opportunities to access ICT and to their use of the Internet for a wide variety of activities." The digital divide can, in other words, also be expressed as the social difference created by the ICT-use where individuals are divided into two groups, where one group have access to the digital world and the other group does not. But it is not just about having access, it is also about having the knowledge about how to use and take advantage of it.

Considerable research has been done on the subject of the digital divide and socioeconomic factors. The gain for business from using ICT on their productivity is equally well covered. The labour market effect for the individuals from using ICT has not been investigated as comprehensively. To raise productivity high level of human capital including ICT-knowledge is crucial. The demand for such individuals has increased in the last two decades. The hypothesis is that the supply has not been sufficient, so the income in Sweden for those individuals has risen more than for others. Since human capital is hard to capture two different proxies are used in this paper, education (both level and subject) and occupation (International Standard Classification of Occupations). A way of reflecting the individuals' competence and ambition will be by their career position. ISCO will thus probably capture more of personal qualities than education; therefore it is assumed to be a better proxy for the competence that is valued in the labour market. Another way of capturing individuals' competence valued on the labour market is to include the income history into the model.

As the ICT-knowledge level is quite high today, it is more interesting to study the time period some years ago. The aim of this paper is to see if individuals with higher ICT-knowledge are doing better in the labour market, than those who might be left behind in the ICT evolution. This analysis is a contribution to this less analysed area. Micro data from the years 2000 and 2003 are used. In this paper focus will not be on the gains for the company, but rather for the individuals on the labour market. The hypotheses is;

The ICT-knowledge has a positive effect on the individual's labour market career.

A positive labour market career is defined as having higher income, higher odds of being employed or lower odds of being unemployed than individuals without ICT-knowledge. This paper is organized as follow: First some earlier works on the subject will be presented. In Section 3 theoretically framework are presented. Chapter 4 describes data. Results are presented in section 5. Finally, conclusions are made in section 6.

2. Earlier studies

The digital divide, internationally

Not only is the income gap bigger in the U.S. than in Sweden. Access to Internet has increased the gap between rich and poor districts in the US (Goslee and Ed, 1998). The incentive to invest in infrastructure in wealthy neighbourhoods where the return was bigger increased the divide. It was even harder than before the ICT revolution for people from poorer areas to be employed as new jobs were created in that field; they were left behind, leaving only low-paid jobs in the service sector, with little chance of climbing the career ladder. Economists David Autor and Lawrence Katz of Harvard and Alan Krueger of Princeton found in their study in 1997 that the spread of computer technology may explain as much as half of the increase in the relative demand for more skilled workers.

The conclusion of Bresnahan, Brynholfsson and Hitt in a study from 1998 was: "A survey of U.S. human resource managers indicating that large investments in information technology lead to changes in organizational practices that decentralize decision-making, increase worker autonomy, and increase the need for highly-educated workers".

In"Measuring the relationship between ICT-use and income inequality in Chile", C. Flores (2003) presented results from a logistic regression on data from 2000. She found that the most important factors for having access to Internet and computer were income, education, area of residence and gender. It was not a big surprising that it turned out to be highly educated workers from metropolitan areas who had most access, but the fact that woman hade more access than men might be a bit more surprising.

Eszter Hargittai (2002) studied individuals, from a suburban county in the USA and their ability to find their way on the Internet, given the same search tasks. There was a great difference between individuals' ability in finding various types of content on the Web and how long they took to complete their online tasks. The most important explanatory characteristics were experience with technology. Young people did better than older ones both in time spent and accomplishment. Highly educated people were more used to downloading and installing software, which required browsing many websites. No gender effect could be found.

Digital divide, Sweden

Around the world, income is one key factor for the digital divide as computers used to be relatively expensive to buy. In 1995 the Swedish Trade Union Confederation (LO, blue-collar workers) wrote an article about how their members were left behind in the digital divide. LO found that only 15 percent of their members had access to a computer in 1994, compared to all workers where the access to a computer was 28 percent. The differences still remained after taking into account sex and age differences.

So in 1998, computers were subsidized by the Swedish government to all employees in the country, in an attempt to lower the digital divide and to increase employability among those already employed. But, a group with even less income was left behind in this respect; those who were unemployed were excluded from access to subsidized computers. Instead unemployed were offered computer educations paid by the government. In 1990 about 10 percent of the population owned a personal computer. Ten years later the proportions hade increased to more then half of the population. The largest increase was among blue-collar workers[1].

Another key factor besides income that shapes the digital divide is the access to fast broadband. The government ambitions were quite high according to the title of the ICT bill in year 2000: "ICT for all, before all other countries"[2]. In these rather early days of the ICT process Sweden used to be one of the "best" with high level of ICT and Internet use among both individuals and firms compared to other countries. Since Sweden is quite sparsely populated, especially in the north, the extension of broadband to all citizens was relatively expensive. Municipalities were subsidized by the Government for the extension of the broadband where there

1 *ITPS, A2003:015*

2 *Näringsdepartementet (2000)*

was no interest from any private operator to invest. The support was issued in 2001 and expired in December 2007. Yet today some people in the most rural areas lack access to Internet, but this will probably be solved with wireless solutions in a near future. An important question; have the Swedish policy measures made the digital divide less severe in Sweden?

In a paper from 2003 Annika Andersson studied different aspects of the digital divide in Sweden. She split the digital divide into four sub themes: Access, Knowledge, Use and Motive, whereas all are essential for the individual to make a meaningful use of the information technology. She studied different obstacles and the possibilities to overcome these and thus to reduce the digital divide. A lot of different factors were tested. She found that education is the single factor that affects individuals Internet uses the most. For accesses to and knowledge about how to use Internet the most crucial factors were having a job or studying, but also having access to broadband. The Swedish Institute for Growth Policy Studies (ITPS, A2003:015) found in their study the same year that the digital divides tended to decrease in Sweden, but some clear gaps still remained, especially among elderly and low educated individuals, even though the gap was shrinking. The opposite was true for individuals with foreign background, where the gap against native Swedes increased.

Demand for skilled workers and productivity

In the U.S. a substantial and growing income differential associated with computer use was found between 1984 and 1989. [3] Further Autor, Katz and Krueger (1998) found evidence for higher demand for college graduates during the period 1970-95 rather than between1940-70. The change in demand was entirely accounted for by an increase in the within-industry change in skill utilization rather than between-industry employment shifts. The skill upgrade took place in industries with greater growth in employee with computer usage, more computers capital per worker, and larger shares of computer investments as a share of total investments. Up to 50 percent of the increase in the growth rate of the relative demand for more-skilled workers since 1970 might be explained by the spread of computer technology. The demand for skilled workers increased both in the U.S. as well as in other OECD nations in the 1980s.

An issue that is often referred to in this context is known as the Solow paradox which was formulated in 1987"You can see computer age everywhere but in the productivity statistics". That seemed to hold for many years. This is however no longer the case since a decade. One Swedish example is an IFAU (The institute for labour market policy evaluation) report from 2004. IFAU found that it was

3 *Krueger (1993)*

crucial that ICT and human capital was on the same level for generating the highest productivity gains. They even found lower productivity when there was a high level in either ICT or human capital compared to if there were low levels in both.

To increase the standard of living it is crucial to raise productivity. A key factor for this is the use of Information and communication technologies (ICT). [4] The same is true for companies to survive in a competitive environment. Considerable studies have been conducted on this subject; the correlation is normally found to be positive between ICT-use and productivity. Hagén and Zeed (2005) found a positive relationship from ICT-use on the productivity, using Swedish microdata from 2003. The level of human capital was also found to have a positive effect on productivity, where human capital was divided into less than three years university and at least three years university. Further education was divided into the fields of data, business or engineering. All fields except data, where no effect could be found, had a positive effect on productivity.

Another firm-level study on the subject was done in U.K. by S. Farooqui[5] (2005). He found that for every additional 10 percent ICT-use among employees, productivity rose by 2.1 percent and every additional 10 percent increase in Internet use among employees raised productivity by 2.9 percent. They used data from the Annual Business Inquiry.

3. Theoretical framework

Mincers's (1974) earnings equation is often used

$$\text{Log } W_i = \beta_0 + \beta_1 * \text{Schooling}_i + \beta_2 * \text{Exp}_i + \beta_3 * \text{Exp}_i^2 + \varepsilon_i$$

where logged income is explained by years of schooling and years of potential labour market experience. Not only experience, but also quadratic function of experience is included in the model, as earnings grew as a concave function of age. This captures the fact that on-the-job training investments decline over time. In this study an extension of Mincers's earnings equation is used. Not only are two different years analysed, but four different setups:

Equation 1, Occupation and ICT

$$Y_i = \beta_0 + \beta_1 * \text{Male}_i + \beta_1 * \text{For}_i + \beta_2 * \text{Age}_i + \beta_3 * \text{Exp}_i + \beta_4 * \text{Exp}_{it}^2 + \beta_{5j} * \text{ISCO}_{ij} + \beta_{6j} * \text{Region}_{ij} + \beta_{7j} * \text{Industry}_{ij} + \beta_{8j} * \text{ICT}_{ij} + \varepsilon_i$$

4 *Robert D. Atkinson (2007)*

5 *Office for National Statistics (ONS, 2005)*

Equation 2, Occupation

$$Y_i = \beta_0 + \beta_1{*}Male_i + \beta_1{*}For_i + \beta_2{*}Age_i + \beta_3{*}Exp_i + \beta_4{*}Exp_i^2 + \beta_{5j}{*}ISCO_{ij} + \beta_{6j}{*}Region_{ij} + \beta_{7j}{*}Industry_{ij} + \varepsilon_i$$

Equation 3, Education and ICT

$$Y_i = \beta_0 + \beta_1{*}Male_i + \beta_1{*}For_i + \beta_2{*}Age_i + \beta_3{*}Exp_i + \beta_4{*}Exp_i^2 + \beta_{5j}{*}EducL_{ij} + \beta_{6j}{*}EducS_{ij} + \beta_{7j}{*}Region_{ij} + \beta_{8j}{*}Industry_{ij} + \beta_{9j}{*}ICT_{ij} + \varepsilon_i$$

Equation 4, Education

$$Y_i = \beta_0 + \beta_1{*}Male_i + \beta_1{*}For_i + \beta_2{*}Age_i + \beta_3{*}Exp_i + \beta_4{*}Exp_i^2 + \beta_{5j}{*}EducL_{ij} + \beta_{6j}{*}EducS_{ij} + \beta_{7j}{*}Region_{ij} + \beta_{8j}{*}Industry_{ij} + \varepsilon_i$$

here Y_i is a measured as the individuals Log total income. The dummy variable Male takes the value one if the person is male, zero if female. Individual with foreign background, For, is defined as foreign if the person was born outside Sweden or in Sweden with both parents born outside Sweden. Age is included to capture non-job experience. Age, experience and squared experience are all continuous variables. Experience is calculated as the year examined minus years since graduation from the last education if higher than previous. Dummies for region (5) and industry (8) are also included as control variables.

Two different specialication are used as proxies for the human capital. Model 1 and 2 explains human capital by occupation (ISCO, International Standards Classification of Occupation). In Model 3 and 4 ISCO is replaced by education, where education is expressed as both level and subject. ICT variables are excluded in Model 2 and 4 so the effect, if any, of including ICT variables can be determined.

Further, two different measurements of the ICT variable were tested. One measures the use of Internet at home and the other measures total Internet use. The first alternative is considered to be a better measurement because the use is to be considered as self-chosen. Whereas the total Internet use from usage at home, at work or at school is a wider definition, it is a better proxy for ICT-skills. However a problem with the total Internet usage might be the correlation with work tasks.

The objective of this paper is to study whether the ICT variable is adding any further information to the extended Mincers's earnings equation above. A simple F-test is used to evaluate if there are any difference between the extended Mincers's earnings equation, Model 1 and 3 compared to the same model without the ICT variable, Model 2 and 4.

$$F = ((R^2_{new} - R^2_{old})/df_1) / ((1 - R^2_{new})/df_2)$$

In the F-test the R-square from respective equation is compared with respect to their degrees of freedom (df). In the first place degrees of freedom are expressed as number of new variables and in the second place, as denominator, n – number of parameters in new model is used.

To capture the non measurable individual characteristics, as well as take into account that individuals with higher income uses Internet more often than individuals with lower income, a model is used taken the income history into consideration;

$\Delta Log(Y_i) = ((Log\ (Y_{i00}) - Log\ (Y_{i97})) – (Log\ (Y_{i03}) - Log\ (Y_{i00}))) = \beta_0 + \beta_1{*}Male_i + \beta_1{*}For_i + \beta_2{*}Age_i + \beta_3{*}Exp_i + \beta_4{*}Exp_{it}^2 + \beta_5{*}ISCO_i + \beta_6{*}Region_i + \beta_7{*}Industry_i + \beta_8{*}ICT_i + \varepsilon_i$

$\Delta Y_i = ((Y_{i00} - Y_{i97}) / (Y_{i97})) = \beta_0 + \beta_1{*}Male_i + \beta_1{*}For_i + \beta_2{*}Age_i + \beta_3{*}Exp_i + \beta_4{*}Exp_{it}^2 + \beta_5{*}ISCO_i + \beta_6{*}Region_i + \beta_7{*}Industry_i + \beta_8{*}ICT_i + \varepsilon_i$

Where $\Delta Log(Y_i)$ is the differences in Log total income and ΔY_i is the difference in the individuals total income between years 1997 to 2000 compared to between 2000 and 2003. The income period before the ICT-survey are compared to the income period after the survey. The hypotheses is that if the individual have a high level of ICT-knowledge, the income shall raise more after the survey than it did in the previous time period when the ICT-use was quite sparsely. As the demand on the labour market for individuals with high ICT-competence is high, their income shall raise more than for an individual with the same background and without high ICT-competence.

Another way of testing the ICT-knowledge effect for the individual on the labour market is to use a logistic model for the probability of being employed or being unemployed.

$E\ (Y) = pr\ (Y{=}1) = 1/\ ((1+\exp(-(\beta_0 + \Sigma\ \beta_j X_j)))$

where the probability for the event to happen, pr (Y=1), is estimated by the exogenous variables X_j. To simplify the analysis the relationship between variables in the logit model are expressed as the odds ratio

$Odds(D) = pr(D)/\ (1-pr(D))$

The odds ratio is the probability for an event to happen divided by the probability that the same event will not happen. In other words the odds ratio describes the odds for the event to occur.[6]

6 *Gujarati (2003)*

4. Data

To create a proxy for the level of ICT-use and ICT-knowledge, the Eurostat Community survey on ICT use by household was used. In Sweden the survey is based on individuals, as Sweden still lack a register on households. The survey has been conducted yearly in Sweden since 2000 and the questions are additional questions to the Labour Force Survey (LFC). Unfortunately it is not possible to follow individuals' ICT-habits over time since new individuals are used for the ICT questions every year. It is even hard to make time-series of a question, since questions are revised in the survey over years, sometimes due to the fast development of ICT which makes older questions meaningless. What are defined as fast and advanced one year can be standard activities some years later.

Two different measurements for the exogenous ICT variable were used. The first ICT- measurement describes how often Internet was used, and the second describes what Internet is used for. To describe how often ICT was used three dummy variables were created, where the value was set to 1 if the individual use the Internet daily, otherwise 0. Dummies were created in the same way as for weekly and monthly ICT-use. How often Internet is used is called ICT-use.

The second exogenous variable is called ICT-knowledge and describes how advanced the individuals' ICT-use was and is thereby expected to be a better measurement of how advanced the ICT-use is compared to the frequency of ICT. In the survey from 2000, the individuals were asked 6 different questions about Internet activities: E-mail, seeking information, discussion-groups, Internet banking, ordering goods or services and to contact authorities. In 2003 more questions were asked, but some where excluded, so the ICT-activities were the same as in 2000.

The data about ICT-use was linked to register data. Register data contains information about individuals' age, gender, immigrant status, level of education, industry, income, residence and so on. Unfortunately no link could be found between the ICT-survey and the register data for the years 2001 and 2002. This fact combined with the burst of the ICT-bubble in 2001 makes 2000 and 2003 the most interesting years to study. The differences between individuals ICT-knowledge in those days was also larger than today, which could make the results more clear. This study will also tell something about how these effects change as the ICT development progresses.

In 2000, 12 238 individuals, aged 16-64 years, were selected from the Labour Force Survey (LFS) sample. 2194 did not answer the questions in the LFS and another 966 rejected the ICT questions. In total 9078 individuals answered the questions in the ICT-survey. Fewer individuals were selected in 2003, only 5504. 864 did not answer the LFS questions and an additional 873 did not answer the ICT questions. Remaining were 3767 individuals who answered the ICT questions. In 2003 the individuals were divided into two groups where 1903 people the questions in questionnaire 1 and the other 1864 answered questions in questionnaire 2. Both questions used in this paper, ICT-use and ICT-knowledge, were included in both questionnaires.

As the effect of ICT-use and ICT-knowledge was reflected on the labour market, restrictions were set on the age variable. To be able to follow the change of the individual's income between two years (with a 3 years lag), the dataset was restricted to contain individuals between the ages of 23 to 62 years, implying that the observations in 2000 dropped from 9078 to 7800. In 2003 the sample was smaller, only 5504 individuals. Number of people who answered the Eurostat Community survey was 3767.

As no data about Individual's International Standard Classification of Occupation (ISCO) were available for the year of 2000 the individual's occupation 2001 were used with ICT-survey and register data from 2000. In 2003 all variables used came from the same year.

The dependent variable income is measured as total income from Employment, Self-employment, Unemployment, Sickness benefit, Parental Leave, VAB (financial compensation from government when individuals are staying home from work to look after a sick child) and study support. To make income normally distributed income is usually logarithmic, that is also the case here. Individuals without income were excluded.

The second measurement of a successful career is to be employed or not being unemployed. A logit model is used to estimate the probability of being employed or unemployed. The measurements for both variables are rough and simple. The definition of employed is having a total yearly income of more than or equal to SEK 120 000 (about EUR 12 500). The levels are not set to high as an attempt to keep part time workers still defined as employed. The income measurement includes income from being employed or self-employed, sick leave, parental leave and VAB (care of children)[7]. The number of observations in 2000 for employed is 5920 while 1486 are not employed. In 2003, 2443 individuals were classified as employed and 470 not employed.

Unemployed are defined as individual's with an unemployment benefits from one year equal to or more than SKR 50 000 (about EUR 5 300). Not all of those who are unemployed are entitled to unemployment benefits. That means that

7 *In Sweden parents have a financial compensation from government when they are staying home from work to look after a sick child*

the measurement is far from perfect. Especially some of the younger people who have never been employed are omitted. The number of observations in 2000 for unemployed individuals is 269 and 7137 is defined as not unemployed. The same figures for 2003; numbers of observations is 120, whereas 2793 are not classified as unemployed.

5. Results

Internet use and income

The demand for skilled workers in the labour market has increased over the last century and during the last two decades another factor has become important, ICT-knowledge. Here the focus is on the gains for the individuals on the labour market. In the first table, results from an extended Mincers' income equation are displayed. In this equations the market incomes were not only explained by exogenous variables education and experience as in the standard case, but further more variables were included, including a proxy for ICT-knowledge. Another setup was used where education, Educ, was replaced by occupation (ISCO). The years studied are 2000 and 2003. In the first table six dummy variables were used as proxies for ICT-knowledge.

Tabel 1 Internet use at home

Dependent Variable Log income	Educ 2000	ISCO 2000	Educ 2003	ISCO 2003
Male	0.22***	0.27***	0.16***	0.23***
Age	0.01***	0.01***	0.01***	0.01***
Foreign background	-0.18***	-0.13***	-0.26***	-0.15***
Upper secondary education	0.13***		0.04	
Post-secondary educaton, less than three years	0.34***		0.09	
Post-secondary-graduated, three years and longer	0.60***		0.22***	
General education, Social sciences, law, commerce, administration	0.07		0.17	
Teaching methods and teacher education	0.19***		0.36***	
Humanities and arts	-0.13		0.09	
Natural science, math and computing	-0.10		0.20	
Engineering and manufacturing	-0.01		0.17	
Health care and nursing, social care	0.27***		0.35***	
Services	0.01		0.24**	
ISCO 1		0.81***		0.82***
ISCO 2		0.82***		0.90***
ISCO 3-4		0.56***		0.68***
ISCO 5		0.46***		0.53***
Experience	0.04***	0.02***	0.01**	0.01**
Experience ^{2}	-0.0007***	-0.0005***	-0.0003***	-0.0003**
Stockholm	0.13***	0.08***	0.16***	0.10***
Big cities	-0.01	-0.02	-0.06*	-0.08**
Smaller regions	-0.06**	-0.05*	0.04	0.03
Public small cities	-0.03	-0.01	0.08	0.05
Private small cities	-0.05	-0.06	-0.03	-0.01
E-mail	0.09***	0.06**	0.09***	0.04***
Read	0.04*	0.04	0.02	0.01
Discussion	-0.09**	-0.09***	-0.09**	-0.04
Bank	0.05**	0.01	0.15***	0.14***
Order	0.07***	0.05**	0.07**	0.06*
Authorities	0.01	-0.004	0.03	-0.08**
8 Industry dummies				
	Adj-R^2=0.20	*Adj-R^2=0.27*	*Adj-R^2=0.15*	*Adj-R^2=0.29*

*Where * for significant at 10 %. ** significant at 5 %, ***significant at 1 %,*

The results displayed in table 1 indicate that there are gains on income for individuals from using Internet at home. One exception is participation in discussion groups (chats) on the Internet which has a negative effect. It seems to that chatting is a leisure activity that do not increase ICT-skills and the socially positive effects are not offset by the time and interest it takes away from other career promoting activities. All other measured usage of the Internet was positive or had no effect on income. Using E-mail had the largest positive effect in 2000. When controlling for ISCO the effect from using E-mail decreased between 2000 and 2003, whereas the effect remained when controlling for education. Due to the more robust education variable over time. In 2003 usage of Internet banks also had a large positive effect. In 2000 that effect was smaller or could not be seen. A significant positive effect could also be seen from ordering goods and services in both years. Reading papers on the internet hade a weak positive effect at one time. No significant effect from using the Internet for filling in documents from authorities could be found in neither of the two years. The stronger effects on the ICT-variables when controlling for education rather than for ISCO could be partly due to the fact that better ICT-knowledge give a career boost which is measured in the ISCO coding. But we do not know which way the endogenity goes. Is it the ICT-knowledge that affects the ISCO coding or is it the ISCO coding that demands higher ICT-knowledge. However, a higher ISCO level could also be due to individual competence not captured by education. The same personal competence and ambition could also have triggered an early adoption of different ICT-activities. In total the true effect lies probably somewhere between the effects registered in the two models. However the ISCO classification should take care of most of these factors since this is directly career related.

When it comes to the business cycle, the two years compared are in a different position. Demand for well-educated individuals was extremely high in the business boom in 2000. This was particularly so for the demand for ICT related activities, and can partly explain the high coefficient values for education level and ISCO that year. The unemployment rate was higher in 2003 and for individuals with foreign background the income fell more than for native Swedes between those years. It comes as no surprises that male, age and experience show a positive effect on income, as well as squared experience had a small negative effect. The same goes for higher educated and higher ISCO coded employees. Living in the local market of the Stockholm region had a significant positive effect, while the opposite was true for smaller regions in 2000, but the significance was not strong. It is a bit surprising that income differences among regions were that tiny, as most of the other regions did not show any significant difference.

In table 1 the effect of Internet use at home is displayed (self chosen Internet use). Table 2 differs from table 1 as the total effect from using Internet is analysed. That means that it did not matter whether the individual used Internet at home, in their working place or in school.

Table 2, Total Internet use

Dependent Variable				
Log income	**Educ 00**	**ISCO 00**	**Educ 03**	**ISCO 03**
Male	0.21 ***	0.27 ***	0.15 ***	0.21 ***
Age	0.01 ***	0.01 ***	0.01 ***	0.01 ***
Foreign background	-0.17 ***	-0.13 ***	-0.25 ***	-0.20 ***
Upper secondary education	0.10 ***		0.02	
Post-secondary educaton, less than three years	0.28 ***		0.05	
Post-secondary-graduated, three years and longer	0.53 ***		0.16 **	
General education, Social sciences, law, commerce, administration	0.05		0.14	
Teaching methods and teacher education	0.19 ***		0.35 ***	
Humanities and arts	-0.14 *		0.07	
Natural science, math and computing	-0.10		0.18	
Engineering and manufacturing	-0.01		0.16	
Health care and nursing, social care	0.27 ***		0.34 ***	
Services	0.02		0.23	
ISCO 1		0.78 ***		0.75 ***
ISCO 2		0.80 ***		0.71 ***
ISCO 3-4		0.54 ***		0.42 ***
ISCO 5		0.46 ***		0.38 ***
Experience	0.04 ***	0.02 ***	0.01 **	0.01 **
Experience ^{2}	-0.0007 ***	-0.0 005 ***	-0.0003 ***	-0.0 002 **
Stockholm	0.12 ***	0.07 ***	0.15 ***	0.12 ***
Big cities	-0.01	-0.02	-0.06 *	-0.07 **
Smaller regions	-0.06 **	-0.05 *	0.04	0.06
Public small cities	-0.03	-0.01	0.08	0.05
Private small cities	-0.06	-0.06	-0.02	-0.02
E-mail	0.19 ***	0.12 ***	0.15 ***	0.06 *
Read	0.01	0.01	0.04	0.03
Discussion	0.01	-0.04	-0.09 **	-0.07 *
Bank	0.02	-0.003	0.16 ***	0.13 **
Order	0.05 **	0.05 **	0.07 **	0.05 *
Authorities	0.05 **	0.02	0.05	-0.02
8 Industry dummies				
	Adj-R^2=0.21	*Adj-R^2=0.27*	*Adj-R^2=0.15*	*Adj-R^2=0.29*

*Where * for significant at 10 %. ** significant at 5 %, ***significant at 1 %*

The correlation between using E-mail and having a high level of education level or being classified as ISCO 2 or 3 is high. Type of educational level and ISCO is also highly correlated to income. The high values for e-mail could therefore, to a great extent, be explained by individuals work tasks. The same is true for work-related discussion in 2000, where the effect from usage at home had a strong negative effect. Participate in a discussion group on the Internet resulted in the biggest change of all ICT variables in its relation to income between 2000 and 2003 in the correlation table. In 2000 the correlation between discussion and income was 0.17; three years later the same correlation was -0.02. Discussion was the only ICT variable among those measured, when looking at what ICT was used for, to be negatively correlated with income. The usage of discussion groups on the Internet between those three years has probably changed from being more exclusive used by researchers to be more used to chat.

Using Internet banking at home in 2000 had some positive effect when controlling for education. The same effect could not be seen when use at work and at schools was included. One explanation could be that a lot of low paid accounting clerks use Internet banking not only in their work, but also at home. Internet banking usage (as all the other ICT-usage areas included) was more common in 2003 than 2000. Users of Internet banks in 2003 had about 15 percentage higher income, all other factors equal, than non users.

Can ICT-use explain any of the differences in income?

An F-test will tell if there are any differences between the models with ICT-knowledge as exogenous variable and the same model without the ICT variables. That is, can ICT-knowledge explain any of the differences in income? The test is performed on all four equations from table 2.

Table 3, F-test, Internet use at home, at work and at school

Dependent Variable Log income	Educ 00	ISCO 00	Educ 03	ISCO 03
F value	29.25 ***	10.81 ***	10.66 ***	3.11 **

*Where * for significant at 10 %. ** significant at 5 %, ***significant at 1 %*

For all models in table 3 one can find that adding ICT-knowledge variables to the models significantly increases the explanatory power of the model. The effect from ICT-knowledge on income is higher in 2000 than three years later. For the ISCO model in 2003 the relationship is true only on the 5 percent significance level. ICT-knowledge variables seem to have greater impact when controlling for education rather than occupation (ISCO). The same picture is given by the correlation matrix, which shows the correlation between ISCO and income is bigger than education level and income. Those differences have already been discussed.

Internet use frequency and income

Until now the focus has been on the ICT-knowledge, measured with a proxy for different tasks preformed on the Internet. Now the focus will be on the frequency of the Internet use. Four different levels of frequency are use; daily, weekly, monthly and less than monthly (including never). The same models as before are used, but with new ICT variables. In table 4 just the coefficients of the ICT-indicator of the use of Internet at home are presented. The complete models are presented in Appendix.

Table 4, Internet use at home

Dependent Variable Log income	Educ 00	ISCO 00	Educ 03	ISCO 03
Daily	024 ***	0.11 ***	0.16 ***	0.04
Weekly	0.11 ***	0.08 ***	0.03	0.03
Monthly	0.08 *	0.10 **	0.03	0.08
	Adj-R^2=0.20	*Adj-R^2=0,26*	*Adj-R^2=0.13*	*Adj-R^2=0.28*

*Where * for significant at 10 %. ** significant at 5 %, ***significant at 1 %*

The Internet-frequency had an impact on income in year 2000. In 2003 the effect was lower, as was the case in table 1 and 2 when Internet knowledge was focused on. There is another implication from using ISCO besides those already mentioned. Individuals who have not entered the labour market do not have an ISCO code, which might explain some of the differences between Educ- and ISCO-model setup. The ISCO code will remain in the register up to five years after last employment.

Table 5, Total Internet use

Dependent Variable Log income	Educ 00	ISCO 00	Educ 03	ISCO 03
Daily	0.31 ***	0.15 ***	0.33 ***	0.15 ***
Weekly	0.14 ***	0.10 ***	0.19 ***	0.12 ***
Monthly	0.09 **	0.09 ***	0.17 ***	0.15 ***
	Adj-R^2=0.21	*Adj-R^2=0.26*	*Adj-R^2=0.15*	*Adj-R^2=0.22*

*Where * for significant at 10 %. ** significant at 5 %, ***significant at 1 %*

When using total Internet use, the dummy variables for Internet frequency indicate both higher significance and coefficient values, than the Internet use at home. Individuals with total Internet use daily have a higher income by as much as 31 percentages than low frequent users. But, once again one can expect that using Internet daily in work are correlated to high ISCO classification and high education level, which is also positively correlated to high income.

Effect from ICT-use some years later

It could of course be advocated that it normally takes some time for the ICT-knowledge, measured with different indicators, to make an impact on the labour market and the individuals' career. But it could equally well be advocated that the same individuals who had a better ICT-knowledge one year probably, in general, also had so a few years earlier. Since all the individuals are replaced from on year to the next in the survey, the ICT-knowledge development between years can not be measured. However another hypothesis has been tested, using the ICT-use indicators from year 2000 and the other variables, including income, from year 2003. In that case also the total ICT-use, not only the use at home, is relevant since it is the historical ICT-use that is measured which is not influenced by the career position three years later.

The result is placed in the Appendix, table 15, where income regressions are using proxies for ICT-knowledge from 2000 and the remaining variables from 2003. Generally this confirms the earlier findings. One interesting exception that appeared though, when taking account of occupation (ISCO), using e-mail in 2000 had no effect on income three years later. The opposite was true for read, where no effect was found analysing income the same year as the ICT-variables. Reading on the Internet in 2000 had a positive effect on income three years later.

Income history

People with higher income have better opportunities to be qualified ICT-users. Therefore it would be interesting to analyse the effect for a high internet user if previously income is taken into account. The Internet use in 1997 was quite limited and few people hade accesses to a computer. In 2000 less than one third of the individuals used Internet daily. The effect from high ICT-use on the labour market should therefore be bigger after 2000 rather than before. Results from using the income differences between 1997 and 2000 and compare that to the income differences between 2000 and 2003 are presented below;

Table 6, Total Internet use

Dependent Variable Diff. Log income	Educ 00	ISCO 00
Daily	0.00	0.07 **
Weekly	0.03	0.04
Monthly	0.11	0.10
	Adj-R2=0.01	*Adj-R2=0.03*

*Where * for significant at 10 %. ** significant at 5 %, ***significant at 1 %*

Table 7, Total Internet use

Dependent Variable Diff. income	Educ 00	ISCO 00
Daily	5.76 **	5.70 **
Weekly	4.36 *	4.12 *
Monthly	-0.13	-0.57
	Adj-R^2=-0.0001	*Adj-R^2=0.001*

*Where * for significant at 10 %. ** significant at 5 %, ***significant at 1 %*

It is harder to explain differences in income rather than levels, therefore the overall fit of the models is extremely low. Actually, one of very few variables that do explain the change in income is ICT. A comparison between Table 6 and 7 shows that when using Log income rather than differences in income fewer ICT variables gets significant. The conclusion made from that is that for those using the Internet daily the gains are bigger for individuals with higher income. When taken into account the historical income development ICT-use matters for income development between 2000 and 2003.

Digital divide and employment

Another question besides the effect on income from the ICT-knowledge is to have a job or not. To analyse if there are any differences in ICT-use between employed and unemployed a logistic model is used. The question to answer here is: are there any signs for digital divides between employed and unemployed in Sweden in 2000 and 2003? Or to put it another way: are individuals with less ICT-knowledge left behind in the new ICT-era?

The ISCO model setup is now excluded as it is correlated to the probability of being employed as well as being unemployed. Not only are the years of 2000 and 2003 analysed, but also the effect of using ICT in 2000 is tested with the other variables from 2003 to test if the effect from high ICT-use and high ICT-knowledge are lagged. Individual's total Internet use is used as the proxy for ICT-knowledge. The odds ratios with levels of significance are presented in Appendix.

Table 8, Employment, odds ratios

	Educ 00 ICT 00	Educ 03 ICT03	Educ 03 ICT 00
E-mail	1.6 ***	1.5 ***	1.3 **
Read	0.9	0.7 **	1.1
Discussion	1.0	1.2	1.0
Bank	1.1	1.3	1.2 **
Order	1.2 **	1.0	1.1
Authorities	1.3 ***	0.9	1.5 ***
Wald chi2	*1016****	*258****	*661****
n/N	*5920/7406*	*2443/2913*	*6171/7684*

*Where * for significant at 10 %. ** significant at 5 %, ***significant at 1 %*

Table 9, Employment, odds ratios

	Educ 00 ICT 00	Educ 03 ICT 03	Educ 03 ICT 00
Daily	2.2 ***	2.0 ***	2.1 ***
Weekly	1.4 ***	1.6 ***	1.6 ***
Monthly	1.3 *	1.9 ***	1.6 ***
Wald chi2	*1009****	*259****	*642****
n/N	*5920/7406*	*2443/2913*	*6171/7684*

*Where * for significant at 10 %. ** significant at 5 %, ***significant at 1 %*

The odds of being employed are twice as high for individuals using Internet daily. Even using Internet weakly or monthly gives higher probability for being employed than using it less often or not at all. That is true for all years. The odds of being unemployed is not that clear. The odds of being unemployed is not significant for 2003 when using ICT-use. For 2000 and the lagged setup for 2000/2003 the odds is significant higher for those using Internet often of being employed.

Unfortunately the measurement of unemployment is not the best, as the criteria for unemployment that was available just include those unemployed who earlier have had a job. Unemployed individuals who have never been working are excluded.

Probability of being Unemployed

Table 10, Unemployment, odds ratios

	Educ 00 ICT 00	Educ 03 ICT 03	Educ 03 ICT 00
E-mail	0.8	0.8	0.9
Read	0.8	0.8	0.8
Discussion	1.3	1.0	1.0
Bank	1.0	1.4	1.1
Order	0.9	0.8	0.9
Authorities	0.9	1.1	0.9
Wald chi2	*200****	*90****	*105****
n/N	*269/7406*	*120/2913*	*312/7684*

*Where * for significant at 10 %. ** significant at 5 %, ***significant at 1 %*

Table 11, Unemployment, odds ratios

	Educ 00 Educ 03 Educ 03		
ICT 00	ICT 03	ICT 00	
Daily	0.6 ***	0.6	0.6 ***
Weekly	0.7 **	0.8	0.7 **
Monthly	1.1	0.6	0.7
Wald chi2	*204****	*88****	*103****
n/N 269/7406	*120/2913*	*312/7684*	

*Where * for significant at 10 %. ** significant at 5 %, ***significant at 1 %*

The difference in the ICT-use between those who are employed and those not employed the same year could be interpreted as the difference between what people do if they are employed or not. The odds of being unemployed are significantly lower for those using Internet at least weekly in 2000. No such difference can be made from frequent Internet use in 2003 or from any of the activities in either year.

Conclusion

This study, based on The Eurostat Community Survey on ICT-use by individuals was linked to register data. Micro data from the years 2000 and 2003 was used. The hypotheses were; The ICT-knowledge has a positive effect on the individual's labour market career? As proxies for ICT-knowledge the frequency of Internet use and different task performed on the Internet were used. Since ICT-knowledge is closely associated with education, the educations levels and orientations had been taken in to account in the analysis. Still there are many individual qualities that are valued on the labour market beyond education and experience that could influence the ICT-knowledge. Thus also the careers measured with the ISCO-classification are used as an alternative to take account more of these factors. Further an historical income development was included as an attempt to take all individual qualities into account.

Our findings indicate that there are income gains for individuals from using Internet at home. One exception is participation in discussion groups (chats) on the Internet which has a negative effect. All other measured usage of Internet had positive or no effect on income. Using E-mail had the largest positive effect in 2000. In 2003 also usage of Internet banking had large impact.

We found positive significant effects on the individuals' career from using the Internet. The effect is larger in 2000 than 2003. Both using Internet often/daily and e-mail use are important for high income and being employed.

When studying total Internet use, that is use at home, in work and at school, the significance and coefficient values were higher overall for the ICT-variables, compared to when analysing only the Internet use at home. Total Internet use daily raise the income by as much as 30 percent. Once again the explanation is due to the fact that using the Internet daily in work is highly correlated to ISCO classification, a high education level as well as to high income. This means that the effect could be due to more qualified work places demands for more ICT-knowledge among their employees.

Adding ICT-knowledge variables to the extended Mincers' wage equation significantly increase the explanatory power of the model, even when taking account of the decrease in the degrees of freedom. The effect from ICT-knowledge on income is higher in 2000 than three years later. We found that the ICT-knowledge variables had greater impact on income when controlling for education rather than occupation (ISCO). The ISCO level does not only reflect the education level of the individual but also positive personal qualities that were valued in the labour market. An even more complex model was used that took the historical income into account. When the historical income development between 1997 and 2000 was used and compare to the income development between 2000 and 2003 (probably with a more frequent ICT-use) revealing that those using internet daily having even higher income development in the later rather then the earlier period. When using previous income as a proxie for market valuation of the personal characteristics ICT-use is one of the most important factors for income development.

Our findings for the odds of being employed are twice as high for individuals using Internet daily. Even using Internet weekly or monthly gives higher probability for being employed than using it less often or not at all. That is true for all years. The odds of being unemployed is not that clear. The odds of being unemployed are not significant for 2003 when using the frequency of the ICT. For 2000 and the lagged setup for 2000/2003 the odds of being unemployed is significant lower for those using Internet often.

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Appendix

Table 12, Correlation, total Internet-use 2000

	E-mail	Read	Discussion	Bank	Order	Authorities
Income	0.19	0.17	0.09	0.14	0.13	0.15
Upper secondary education	-0.14	-0.11	-0.11	-0.03	-0.09	-0.14
Post-secondary educaton, less than three years	0.16	0.14	0.07	0.07	0.08	0.10
Post-secondary-graduated, three years and longer	0.24	0.22	0.18	0.10	0.17	0.24
ISCO 1	0.10	0.08	0.08	0.09	0.06	0.08
ISCO 2	0.23	0.21	0.18	0.12	0.17	0.22
ISCO 3	0.16	0.13	0.04	0.08	0.06	0.11
ISCO 4 & 5	-0.19	-0.17	-0.11	-0.11	-0.10	-0.14

Table 13, Correlation, total Internet-use, 2003

	E-mail	Read	Discussion	Bank	Order	Authorities
Income	0.13	0.09	-0.02	0.10	0.13	0.11
Upper secondary education	-0.11	-0.10	-0.03	-0.06	-0.11	-0.14
Post-secondary educaton, less than three years	0.14	0.06	0.04	0.05	0.14	0.10
Post-secondary-graduated, three years and longer	0.21	0.17	0.04	0.06	0.21	0.18
ISCO 1	0.08	0.00	0.02	0.06	0.08	0.09
ISCO 2	0.21	0.17	0.01	0.06	0.21	0.20
ISCO 3	0.18	0.06	0.02	0.02	0.18	0.08
ISCO 4 & 5	-0.17	-0.12	-0.05	-0.06	-0.17	-0.14

Table 14, Correlation, Total Internet-use 2000

	Daily	Weekly	Monthly
Income	0.21	-0.02	-0.03
Upper secondary education	-0.15	0.02	0.06
Post-secondary educaton, less than two years	0.13	0.03	-0.01
Post-secondary-graduated, three years and longer	0.24	0.00	-0.04
ISCO 1	0.15	-0.03	-0.05
ISCO 2	0.25	-0.02	-0.04
ISCO 3	0.17	-0.00	-0.05
ISCO 4 & 5	-0.20	-0.01	0.07

Table 15, Correlation, Total Internet-use 2003

	Daily	Weekly	Monthly
Income	0.14	-0.03	-0.02
Upper secondary education	-0.15	-0.03	-0.01
Post-secondary educaton, less than three years	0.11	-0.00	-0.05
Post-secondary-graduated, three years and longer	0.17	-0.01	-0.06
ISCO 1	0.10	-0.03	-0.02
ISCO 2	0.21	-0.05	-0.09
ISCO 3	0.17	-0.02	-0.05
ISCO 4 & 5	-0.19	0.02	0.05

Table 16, Complete Table 4, Internet-use at home

Dependent Variable Log income	Educ 00	ISCO 00	Educ 03	ISCO 03
Male	0.21 ***	0.27 ***	0.16 ***	0.24 ***
Age	0.01 ***	0.01 ***	0.01 ***	0.01 ***
Foreign background	-0.18 ***	-0.13 ***	-0.27 ***	-0.15 ***
Upper secondary education	0.12 ***		0.05	
Post-secondary educaton, less than three years	0.32 ***		0.10	
Post-secondary-graduated, three years and longer	0.57 ***		0.23 ***	
General education, Social sciences, law, commerce, administration	0.06		0.15	
Teaching methods and teacher education	0.21 ***		0.35 ***	
Humanities and arts	-0.13		0.08	
Natural science, math and computing	-0.11		0.17	
Engineering and manufacturing	-0.01		0.16	
Health care and nursing, social care	0.27 ***		0.33 ***	
Services	0.01		0.22 *	
ISCO 1		0.80 ***		0.82 ***
ISCO 2		0.82 ***		0.90 ***
ISCO 3-4		0.56 ***		0.68 ***
ISCO 5		0.46 ***		0.53 ***
Experience	0.04 ***	0.02 ***	0.01 **	0.01 **
Experience ^{2}	-0.0007 ***	-0.0005 ***	-0.0003 ***	-0.0 003 **
Stockholm	0.12 ***	0.08 ***	0.15 ***	0.09 ***
Big cities	-0.01	-0.02	-0.07 *	-0.08 **
Smaller regions	-0.06 **	-0.05 *	0.04	0.03
Public small cities	-0.02	-0.01	0.08	0.05
Private small cities	-0.05	-0.06	-0.03	-0.02
Daily	0.24 ***	0.11 ***	0.16 ***	0.04
Weakly	0.11 ***	0.08 ***	0.03	0.03
Monthly	0.08 c	0.10 b	0.03	0.08
8 Industry dummies				
	Adj-R^2=0.20	*Adj-R^2=0.26*	*Adj-R^2=0.13*	*Adj-R^2=0.28*

*Where * is significant at 10 %. ** significant at 5 %, ***significant at 1 %*

Table 17, Complete Model 5, Internet-use at home, at work and at school

Dependent Variable Log income	Educ 00	ISCO 00	Educ 03	ISCO 03
Male	0.21 ***	0.27 ***	0.15 ***	0.21 ***
Age	0.01 ***	0.01 ***	0.01 ***	0.01 ***
Foreign background	-0.17 ***	-0.13 ***	-0.24 ***	-0.19 ***
Upper secondary education	0.10 ***		0.01	
Post-secondary educaton, less than three years	0.27 ***		0.04	
Post-secondary-graduated, three years and longer	0.52 ***		0.16 *	
General education, Social sciences, law, commerce, administration	0.04		0.12	
Teaching methods and teacher education	0.21 ***		0.33 ***	
Humanities and arts	-0.13 *		0.05	
Natural science, math and computing	-0.12		0.16	
Engineering and manufacturing	-0.02		0.15	
Health care and nursing, social care	0.27 ***		0.32 ***	
Services	0.02		0.21 *	
ISCO 1		0.78 ***		0.74 ***
ISCO 2		0.80 ***		0.72 ***
ISCO 3-4		0.54 ***		0.42 ***
ISCO 5		0.46 ***		0.39 ***
Experience	0.03 ***	0.02 ***	0.01 ***	0.01 **
Experience ^{2}	-0.0007 ***	-0.0005 ***	-0.0004 ***	-0.0003 **
Stockholm	0.11 ***	0.08 ***	0.15 ***	0.12 ***
Big cities	-0.01	-0.02	-0.07 *	-0.07 **
Smaller cities	-0.06 *	-0.05 *	0.04	0.05
Small cities, Public	-0.02	-0.01	0.08	0.06
Small cities, Private	-0.05	-0.06	-0.01	-0.02
Daily	0.31 ***	0.15 ***	0.33 ***	0.15 ***
Weekly	0.14 ***	0.10 ***	0.20 ***	0.12 ***
Monthly	0.09 **	0.09 ***	0.17 ***	0.15 ***
8 Industry dummies				
	Adj-R^2=0.21	*Adj-R^2=0.26*	*Adj-R^2=0.15*	*Adj-R^2=0.22*

*Where * is significant at 10 %. ** significant at 5 %, ***significant at 1 %*

Table 18, Internet-use at home, at work and at school

Dependent Variable Log income	**IT 2000 Educ 03**	**IT 2000 ISCO 03**	**IT 2000 Educ 03**	**IT 2000 ISCO 03**
Male	0.15***	0.21***	0.16***	0.22***
Age	0.02***	0.01***	0.01***	0.01***
Foreign background	-0.14***	-0.11***	-0.15***	-0.11***
Upper secondary education	0.07**		0.07**	
Post-secondary educaton, less than three years	0.11***		0.12***	
Post-secondary-graduated, three years and longer	0.28***		0.29***	
General education, Social sciences, law, commerce, administration	-0.09		-0.10	
Teaching methods and teacher education	-0.05		-0.05	
Humanities and arts	-0.26***		-0.26***	
Natural science, math and computing	-0.14*		-0.15*	
Engineering and manufacturing	-0.05		-0.06	
Health care and nursing, social care	0.07		0.07	
Services	-0.08		-0.09	
ISCO 1		0.61***		0.62***
ISCO 2		0.53***		0.54***
ISCO 3-4		0.35***		0.36***
ISCO 5		0.26***		0.26***
Experience	0.01***	0.01**	0.01***	0.01**
Experience ^{2}	-0.0004***	-0.0003***	-0.0004***	-0.003***
Stockholm	0.13***	0.09***	0.13***	0.10***
Big cities	0.02	0.02	0.03	0.02
Smaller cities	-0.07***	-0.07***	-0.07***	-0.07***
Small cities, Public	-0.15**	-0.11*	-0.14**	-0.10
Small cities, Private	-0.08	-0.08	-0.07	-0.07
E-mail	0.09***	0.04		
Read	0.04	0.05**		
Discussion	0.01	-0.02		
Bank	0.06***	0.04*		
Order	0.03	0.02		
Authorities	0.09***	0.07***		
Daily			0.25***	0.13***
Weakly			0.14***	0.11***
Monthly			0.11***	0.10***
8 Industry dummies				

Adj-R^2=0.15 Adj-R^2=0.19 Adj-R^2=0.15 Adj-R^2=0.18
*Where * is significant at 10 %. ** significant at 5 %, ***significant at 1 %*

Developing and implementing a survey on intermediate consumption for the service sector in Sweden

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Abstract

Information about intermediate consumption for the service sector is an important input to the National Accounts. Up until now there has been no regular data collection in this area. From the Structural Business Statistics (SBS) information about *Raw materials and consumables* and *Other external expenses* are collected. These two aggregated variables are then to be further specified. To collect data on *Raw materials and consumables* a gross list of goods and services, that are considered common to each sector, is provided. Different kind of sources is used for this purpose as the Combined Nomenclature (CN), income and cost statements, information from branch organizations and product groups that National accounts have in there supply and use tables. To collect data on *Other external expenses*, information from the income- and cost statement have been used which is combined to Swedish general chart of accounts (BAS) which is a commonly used by almost every small- and medium sized enterprises in Sweden. From the SBS we have estimates of our main variables based on known values from the Swedish Tax Agency.

The pilot survey of intermediate consumption is done for the third time for the reference year 2007. The first pilot survey was done for the following activities; hotel and restaurants, wholesale trade, real estate services, telecommunications, legal and accounting services and advertising services. The data in this pilot survey was collected on a separate questionnaire. In the second pilot survey for the reference year 2006 all data was collected in the SBS survey. The following three

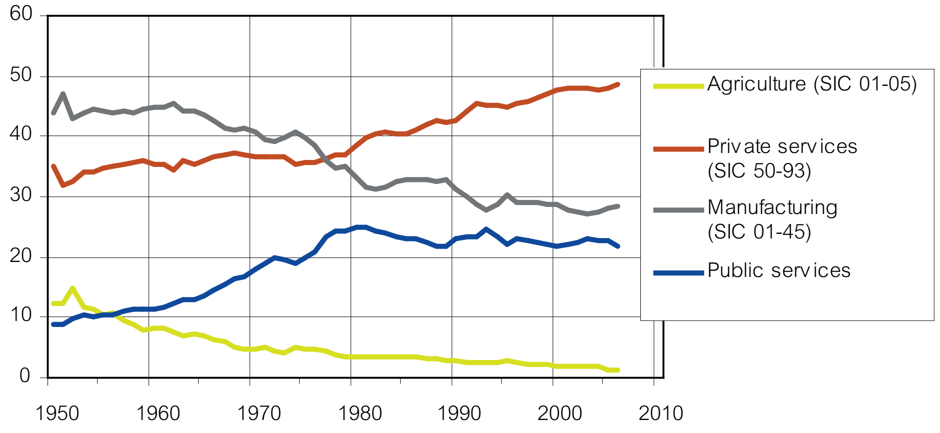
activities were covered; motor vehicle trade, recreation, culture and sport activities and other services.

For the reference year 2007 all data will be collected within the SBS survey. The data for *Other external expenses* will be collected in the SBS survey and the data for *Raw material* will be collected by telephone follow up to these enterprises that have filled values for that variable in the SBS.

1. Introduction

During the last 30 year Sweden has gone from being a manufacturing nation to more and more become to a service producing nation. In the beginning of 1950 was 35 per cent of the value added coming from from the service sector and 45 per cent from the manufacturing sector. In the year 2006 it was the other way around and 49 per cent of the value added in the Swedish economy was coming from the service sector and 29 per cent of the value added from manufacturing sector.

Share of value added in current prices 1950-2006, by sector



The statistics for the service sector has not followed the change in the economy and there is still much more statistics for the manufacturing sector compared to the service sector.

Information about the intermediate consumption for the service sector is an important input to the National Accounts for the calculation of supply and use tables. Up until 2005 there has been no regular data collection in this area. The National Accounts have instead been forced to work with different assumptions in their calculations of the Gross Domestic Product (GDP). In order to handle this shortage a project started within Statistics Sweden to develop and implement a new survey. Focus of the survey is to measure the product breakdown on intermediate consumption in order to get a good picture of the variation of production of goods and services within the service sector. The Structural Business Statistics (SBS) produce estimates of *Expenses for raw materials and consumables* and *Other external expenses*. These two aggregated variables are to be further specified in the survey on intermediate consumption for the service sector (ICS). The development of the ICS has therefore been closely linked to the SBS.

2. National accounts

The Gross domestic product (GDP) is the value of all goods and services which is produced within the country for the use for consumption, investments and export during a period. GDP is measured at market prices and is the sum of all the industries' taxed value added, plus product taxes (value added tax, alcohol tax, etc.) minus product subsidies.

The level of value added is defined in the European System of Accounts (ESA) for each, such as the following:

VA = production ***minus*** intermediate consumption

or in greater detail, one might write

VA = Turnover ***minus*** business costs
plus changes to inventory
plus capital formation by the producer

The intermediate consumption of goods and services is calculated within the national accounts in something that is called supply- and use tables. Supply and use tables is composed of activity- and product matrices which in detail describe the domestic production processes and transaction with products within the country. These tables show:

- the structure of the production costs and the income which is generated within the production process,
- the flow of goods and services which is produced within the country's economy,
- the flow of goods and services into and from foreign countries

The calculations within the supply and use tables in Sweden are done for approximately 400 product groups and 135 activity groups. In annex 1 an extract of this for the activity of computer services can be seen. The service sector is calculated for 41 activities.

Information about the intermediate consumption for the service sector is an important input to the National Accounts for the calculation of supply and use tables. The level of the Intermediate consumption in each activity is taken from the Structural business statistics. Up until now there has been no regular data collection in this area for breakdown on product groups. The National Accounts have instead been forced to work with different assumptions in their calculations of the intermediate consumption for the service sector.

3. Survey on intermediate consumption (ICS) 2005

3.1 Developing the survey for reference year 2005 on intermediate consumption

3.1.1 Structural Business Statistics at Statistics Sweden

The Structural Business Statistics[1] (SBS) is an EU-regulated survey carried out on a yearly basis. Statistics Sweden has recently implemented a new method for the SBS. A key factor of this new method is the use of administrative data from the Swedish Tax Agency (SRU) to a larger extent than before. From the SRU certain main variables such as *Sum of expenses for raw materials and consumables* and *Other external expenses* can be derived for every object in the population of interest in the SBS. The quality, though, of the cost specification in the SRU is considered low so total cost (the sum of the cost variables) is used in the SBS. In fact, the sums of those totals are used as known population totals in the estimation phase. Additional primary data collection is needed within the SBS to meet the demands from the National Accounts and the SBS regulation. But this additional data collection is limited to obtain estimates of desired relative distributions such as total costs divided into components, rather than estimates of unknown totals. The SBS produces separate estimates of the variables, *Expenses for raw material, Expenses for resale* and *Other external expenses* (divided into a few further specified components) based on information from all large enterprises complemented with information from small enterprises based on a sample survey. The use of known population totals in the estimation phase means that an efficient estimator can be used and the sample sizes can be kept relatively small. This is, of course, a positive thing with respect to the imposed response burden.

3.1.2 A survey on intermediate consumption

The study variables in the survey on intermediate consumption (ICS) are, as already mentioned, further specifications of the two aggregated variables *Expenses for raw materials* and *Other external expenses.* Within the SBS some of the specifications concerning other expenses already are collected, such as:

- Freight and transports
- Temporary manpower
- Computer program
- Rent for premises
- Purchased services and cost of administration
- Advertising and PR
- Other

It is the variables *Other* and *Purchased services and cost of administration in Other expenses* that is the main target for this survey for reference year 2005 together with the variable *Expenses for raw materials.*

It became clear, when comparability was considered, that the ICS should focus on producing estimates of relative distributions on the further specifications of the three variables *Expenses for raw material, Purchased services and cost of administration* and *Other* instead of producing level estimates of the specifications. Level estimates produced by ICS would mean discrepancies between those level estimates and the level estimates produced by the SBS regarding the three aggregated variables (the same reference year). For the same reason it is advisable to use the estimated population totals from the SBS as known population totals in the ICS. An alternative would be to use the known population totals from the SRU (of total costs) in the estimation phase but this would also mean discrepancies. An additional argument, apart from comparability, for using estimated population totals from the SBS as known population totals in the ICS is the fact that the total sample size in the ICS can be kept small. The sample size in the SBS is fairly large (compared to the planned sample size in the ICS) and the produced level estimates of the aggregated variables are therefore of quite high quality. To make use of those estimated population totals in the estimation phase makes it possible to keep the total sample size in the ICS down.

ICS also collects information on *Expenses for resale* and the rest of the components (apart from *Other* and *Purchased services and cost of administration)* of *Other external expenses* in order to have information about the total cost for each enterprise in the sample. This information is mainly used for editing purposes and to make it possible to verify that the collected information agrees with the information collected in the SBS.

In order to explore the possibility to implement a future survey, limited to produce estimates of relative distributions, a pilot survey was conducted.

3.2 The pilot survey for 2005 on intermediate consumption in the service sector

There were several objectives of the pilot survey:

- the possibility to collect the required information from the enterprises
- get feed-back from the respondents on the questionnaire design
- estimate relative distributions of *other external expenses* from the pilot survey and compare them with the estimated distributions from the SBS. The comparison will indicate if estimated relative distributions can be used together with the level estimates from the SBS

- to get a picture of what kind of *raw materials* and type of *other external expenses* that are used in each sector
- explore the structure of the expenses, is it similar for all enterprises in the same sector, is it the same for small and large enterprises
- estimate relative distributions and population totals of the specifications and give the National Accounts to explore

The objective of the pilot survey was to shed light over several things and the design of the pilot survey could therefore not be optimized for any specific purpose. It was voluntary for the enterprises to participate in this pilot survey.

The pilot survey included seven industries within the service sector, Swedish industry classification 2002 (SIC), see table 1. These sectors are the domains of study in the pilot survey.

Table 1

SIC	Activity
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles
55.1+55.2	Hotels + Camping sites etc.
55.3+55.5	Restaurants + Canteens and catering establishments
64.2	Telecommunications
70	Real estate activities
74.1	Legal, accounting, book-keeping and auditing activities; tax consultancy; market research and public opinion polling; business and management consultancy; holdings
74.4	Advertising

3.2.1 Design of the pilot survey

3.2.1.1 Questionnaire design

It looks very different from sector to sector concerning how much that needs to be further specified. In some sectors there exist no *raw materials* at all whereas in other sectors there is a fairly large amount of *raw materials*. This indicates that since the structure of the intermediate consumption is very different from sector to sector tailor-made questionnaires have to be developed. The key to a successful survey is the quality of the list of goods. You have to attain knowledge about every sector. Constructing a good product list is probably the most difficult part.

In order to get a picture of how easy it would be to find the information from the enterprises the income- and cost statements have been used. It turned out that a lot of information could be found and the assumption was made that regarding the specification of *other expenses* it seemed fairly easy for the respondents. By reading some income- and cost statement for the different sectors a list of variables could be produced. References to an in Sweden commonly used general chart of accounts (BAS) are pre-printed on the questionnaires in order to facilitate for the respondents. Another measure to lower the response burden was to offer the respondents to send their income- and cost statements instead of filling in the questionnaire. Staff at Statistics Sweden then used that information to fill in the questionnaires.

For *raw materials* on the other hand the information could not be found in the income- and balance sheet statements. Instead the gross list of goods and services that are considered common to each sector had to be provided from other sources. The Combined Nomenclature (CN) has been used for this purpose. The list itself has been produced by using a lot of different sources like PRODCOM, data on import and export, annual reports from large enterprises, trade associations and interviews with different enterprises.

The National Accounts in Sweden have about 400 groups of products so the least specified classification of goods which we are able to use are the National Accounts groups of products.

In the pilot survey only one questionnaire per sector was used. For SIC 51 no list of pre-printed goods and services were provided. Instead the enterprises were left with a number of open rows with a request for filling in the goods themselves. The reason was that within SIC 51 there is a lot of diversified business activity and that would have meant a tailor-made questionnaire for almost every enterprise. Except for SIC 51 only SIC 64.2 and 55 had a significant amount of *raw materials*. For SIC 553+5 the decision was made to try to use some other sources to calculate the product breakdown as an alternative.

3.2.1.2 Different method for Hotels and Restaurants

In Statistics Sweden information from food and beverage sales statistics together with the Swedish institute for agriculture's (SJV) statistics on food consumption within the retail trade, large-scaled households and restaurants have been used. In the intermediate consumption questionnaire only questions about food, coffee, alcoholic beverages (divided into beer, wine and spirit) and non-alcoholic beverages were asked. To get a more detailed list for food the above mentioned sources were used. The calculations were made by:

- using information on quantities from SJV for food consumption. These quantities were multiplied with figures on prices from retail trade gathered from a private company (AC Nielsen) together with information from SJV calculations on prices (value/quantity)
- subtracting the calculated value from above from the calculated value from the sales statistics on food and beverage

The residual item is then supposed to be the intermediate consumption for large-scaled households and restaurants.

3.2.1.3 Frame population

The frame population consisted of all active enterprises in the Swedish Business Register (BR) classified into the economic activities SIC 51, 55.1, 55.2, 55.3, 55.5, 64.2, 70, 74.1 and 74.4 and into the business sector in November year 2005. The classification into the business sector was based on the institutional sector code. The total frame population consisted of 189 378 enterprises.

3.2.1.4 Cut-off limit

The objective of this pilot survey was to shed light over various aspects and this means that different kind of enterprises should be included in the sample (not only enterprises with the largest impact on estimates of the study variables). The smallest enterprises, though, were not included because their impact on the estimates is very small and they often lack the requested information in their accounting systems. The cut-off points in this pilot survey were set to keep a reasonably proportion, in terms of coverage, of the frame population in the surveyed population.

The known values of total cost from the SRU (on the enterprise level) were used as a size measure. Total cost is dominated by resale in SIC 51 and this variable is not part of the study variables in the ICS. Resale could be excluded from the size measure by information collected from another source (this information is only available for SIC 51). To be part of the surveyed population enterprises must have at least one million SEK (70, 74.1), two million SEK (55.3+5, 74.2) or five million SEK (51, 55.1+2, 64.2) in total cost year 2004. All enterprises must, besides the cost criterion, have at least one million SEK in annual turnover to be part of the surveyed population. After cut-off the surveyed population consisted of 18 856 enterprises.

3.2.1.5 Stratification of the pilot survey

The domain stratification was based on economic activity. The structure of the cost specification varies between the four-digit levels within SIC 74.1 To be sure to have enterprises from each four digit-level in the sample the domain stratification were adapted (despite the fact that the domains consisted of the three-digit level). In SIC 51 large enterprises were stratified on the three-digit level just to make sure to have enterprises from all three-digit levels in the sample. Each domain stratum was then divided into three size strata, consisting of small, medium and large enterprises. The size measure used was the known total cost values from the SRU (resale excluded in SIC 51). The specific cut-off points for the size groups depend on the economic activity. Large enterprises, in terms of costs, were completely enumerated.

3.2.1.6 Allocation and estimation

In this pilot survey the allocation of the sample were very simple, complete enumeration among the large enterprises and 25 enterprises selected in each of the sampled size groups in SIC 51 and 55. Regarding the rest of the sectors (the sample for SIC 51 and 55 were drawn at an earlier time point) the total sample size was slightly larger and therefore larger samples were taken in size groups consisting of many enterprises. The stratification and allocation of the sample is shown in table 2 (N = number of enterprises in population, n = number of enterprises in sample):

Table 2 Population and sample in the ICS

		Size Group			
SIC	Data	1	2	3	Total
51	N	2 312	289	54	2 655
	n	25	25	54	104
551+2	N	384	103	8	495
	n	25	25	8	58
553+5	N	2 515	563	8	3 086
	n	25	25	8	58
642	N	92	10	16	118
	n	20	10	16	46
70	N	7 054	343	31	7 428
	n	100	75	31	206
7411	N	388	63	28	479
	n	30	20	28	78
7412	N	540	89	15	644
	n	30	20	15	65
7413	N	69	23	21	113
	n	18	20	21	59
7414	N	2 287	252	23	2 562
	n	75	40	23	138
744	N	1 075	168	33	1 276
	n	125	50	33	208
Total N		16 716	1 903	237	18 856
Total n		473	310	237	1 020

A simple random sample of size *n* was drawn in each stratum. Relative distributions (proportions) in each sector calculated from this pilot survey were estimated by a ratio, where numerator and denominator were estimated separately by a Horvitz-Thompson estimator. Non-response is compensated by re-weighting within each stratum (responding enterprises are seen as a simple random sample within each stratum from the surveyed population).

3.3 Results from the pilot survey

Questionnaires were sent out to the enterprises included in the sample regarding SIC 51, 55.1+2 and 55.3+5 in spring year 2006 and to the enterprises included in the sample regarding SIC 64.2, 70 and 74.1 and 74.4 in autumn the same year. Enterprises who did not return their questionnaire were reminded by postal mail and by telephone. When the data collection was finalized number of returned questionnaires were 572 which means 56.1 % in terms of number of questionnaires, see table 3.

Table 3 Number of returned questionnaires

SIC-Group	Number in sample	Number of Responses[1]	Unweighted	Weighted[2]
51	104	74	71,2	67,5
551+2	58	38	65,5	88,7
553+5	58	23	39,7	53,3
642	46	19	41,3	19,4
70	206	130	63,1	68,8
741	340	197	57,9	64,2
744	208	91	43,8	47,5
Total	1 020	572	56,1	67,6

1 Including 32 closed down enterprises
2 In terms of the size measure

3.3.1 Bias due to non-response

As mentioned before, it was voluntary for the enterprises to participate in this pilot survey. In order to evaluate the quality of the results, especially in terms of possible bias caused by the low response rate, the known total cost variable (resale excluded in SIC 51) from each enterprise were used. Information on this variable (x) is known for the whole surveyed population and could be aggregated to known population totals, t_x, for each SIC-group. This variable is of course also known for the enterprises included in the sample, whether they returned their questionnaire or not. Estimated population totals, $\hat{t}_x$, for the total costs were produced for each SIC-group, one based on the responding enterprises in the sample and one based on all enterprises in the sample, se table 4. Non-response was compensated by re-weighting within each stratum (responding enterprises were seen as a simple random sample within strata from the surveyed population). Table 4 shows that a 95% confidence interval based on responding enterprises covers the known population total in each SIC-group (except one). This indicates that bias caused by non-response is small. An explanation to the low response rate in SIC 64.2 could be that the list of products concerning *raw materials* was very long (about 20 different products) which may have"scared off "some enterprises. An additional problem in SIC 64.2 was that one dominating enterprise did not respond. The result shown in table 4 indicates that it is possible to draw some conclusions about the whole surveyed population based on the results from this pilot survey (except for SIC 64.2).

Table 4 Known information on total cost (resale excluded in SIC 51) aggregated to population totals and those population totals estimated by the sample (million SEK)

SIC-Group	Known population Total	Estimates based on returned questionnaires				Estimates based on the total sample			
		Point Estimate	Standard Error	Confidence interval Lower	Upper	Point Estimate	Standard Error	Confidence interval Lower	Upper
	t_x	$\hat{t}_x$	$\sqrt{V(\hat{t}_x)}$			$\hat{t}_x$	$\sqrt{V(\hat{t}_x)}$		
51	84 752	85 540	7 403	71 030	100 051	84 335	5 470	73 613	95 057
551	10 339	11 540	765	10 041	13 038	10 304	417	9 487	11 121
553	20 231	19 545	2 618	14 414	24 677	19 319	1 604	16 175	22 462
642	58 781	33 054	7 720	17 923	48 185	61 087	1 034	59 059	63 114
70	95 860	89 264	7 345	74 868	103 660	89 745	5 481	79 001	100 488
741	28 978	29 466	1 547	26 434	32 498	27 762	940	25 920	29 604
744	24 975	24 404	2 782	18 953	29 856	24 169	480	23 229	25 109

3.3.2 Conclusions from the pilot survey

Even if the response rate was a bit lower than expected some valuable results of the functioning of the questionnaire could be derived. A very low amount of *Other external expenses* are now found under *Other* which indicates that the pre-printed variables have worked in a satisfying way. This was one of the objectives of the pilot survey. These results can clearly be seen in table 5.

Table 5 Proportion of Other in Other external expenses unspecified in the SBS and in the ICS

SIC-Group	Other external expenses	
	Unspecified in SBS	Unspecified in ICS
51	44,5%	6,1%
551	35,1%	1,7%
553	41,9%	3,1%
70	27,2%	9,7%
741	66,3%	9,8%
744	27,6%	8,3%

The same conclusion can be drawn from the results for *Purchased services and cost of administration* and *expenses for raw materials* in SIC 51 and 55 see table 6 and table 7 below.

Table 6 Distribution of Purchased services and cost of administration

Variable	SIC 51 (%)	SIC 551+2 (%)	SIC 553+5 (%)
Cost of administration, management fees	22,2	25,8	32,0
Accounting services, legal costs	2,4	11,2	13,9
Information technology services	16,7	20,5	5,4
Other consultancy services	33,8	13,9	8,1
Technological consultancy services	5,0	4,7	
Bank services	3,1	10,2	21,3
Research and development	4,0	0,0	3,2
Other	12,8	13,7	16,1

Table 7 Distribution of Expenses for raw materials and consumables

Variable	SIC 51, %	SIC 551+2, %	SIC 553+5 %
Specified in SIC 51	88,8		
Food and coffee		57,9	63,0
Beer		6,1	14,7
Wine		7,4	7,7
Spirits		3,5	6,4
Non-alcoholic beverages		2,3	3,8
Other	11,2	22,9	4,4

Some checking has also been made towards the SBS and especially the SRU. The checking is done by editing the level of *Expenses for raw materials and consumables, Purchased services and cost of administration* and *Other external expenses*. In case there is a difference checking is made towards the annual report and as a last way out the enterprise is contacted. In table 8 below a comparison between the estimated cost distribution (%) from the SBS and the estimated cost distribution (%) from the ICS (regarding variables included both in the SBS and in the ICS) is shown. All possible variables are not included in the table, only variables with a significant proportion.

Table 8 Estimated relative distribution (%) of the cost variable *Other external expenses* from the SBS and from the ICS

SIC 51	SIC 551+2		SIC 553+5		SIC 70	SIC 741		SIC 744				
Variable	**ICS**	**SBS**	**ICS**	**SBS**	**ICS**	**SBS**	**ICS**	**SBS**	**ICS**	**SBS**	**ICS**	**SBS**
Other exp. for rent and lease of fixed assets	1,0	0,2	2,2	0,6	4,7	0,0	0,5	0,1	2,9	0,2		
Freight and transports	17,1	13,0	0,2	0,3	0,3	1,2	0,1	0,1	1,2	1,6	0,6	0,9
Temporary manpower	2,1	1,5	1,8	1,3	4,1	1,1	0,2	0,6	4,2	2,8	0,6	1,4
Computer program	0,5	0,5	0,2	0,3	0,3	0,2	0,2	0,2	2,0	0,9	0,2	0,3
Other articles for consumptions	1,0	1,2	1,3	2,3	1,4	4,0	0,6	0,4	1,9	1,5	0,5	0,6
Rent for premises	7,7	9,9	47,7	47,2	35,8	41,7	9,3	4,2	22,4	19,2	3,3	6,6
Purchased services and cost of adm.	20,0	9,9	4,8	3,0	6,4	2,6						
Advertising and PR	14,9	15,1	6,0	4,9	3,8	4,5	3,6	2,0	13,5	4,1	4,3	3,0
Repair and maintenance of house property	1,0	0,8	3,4	2,0	3,3	0,3	23,1	28,3	1,1	0,4	0,3	0,1
Energy (heat, cool and lighting included)							33,0	27,6				
Real estate tax							6,3	4,6				
Intermediate cost of supplying adv. space or time on a fee or contract											76,1	57,5
Other	29,2	44,5	30,0	35,1	35,7	41,9	18,2	27,2	42,2	66,3	13,1	27,6

These results show that there are coherences between the SBS and the results from the ICS. However, the ICS has a larger proportion distributed on Purchased services and cost of administration in SIC 51 and 55. The proportion of distributed costs is roughly twice the size of the proportion of distributed costs in the SBS. An explanation of the difference could be that the enterprises seem to be able to specify more in detail when the questionnaire is more detailed. In the ICS the variable Purchased services and cost of administration consist of eight different variables. Another reason for the larger proportion of distributed costs in the ICS can be the reference to the general chart of accounts (BAS). Those references are pre-printed on the questionnaires and are therefore more easily obtained than in the SBS.

The variable Advertising and PR in SIC 741 follows the same pattern. The distribution in the ICS regarding this variable is larger then the distribution of the same variable in the SBS. Also here it can be a result of the design of the questionnaire. In the ICS, the variable Advertising and PR consists of five variables instead of one variable as in the SBS. The enterprises in this sector also seem to be able to specify more in detail when the questionnaire is more detailed.

As a general conclusion the enterprises seem to be able to specify more in the ICS than in the SBS. An explanation of this can be the questionnaire design which requests the enterprises to specify more in detail. In SIC 744, for example, the enterprises have distributed 76 % of their total cost in the ICS on the variable Intermediate cost of supplying advertising space or time on a fee or contract but only 58 % of their total cost on the same variable in the SBS. In all sectors there is a smaller proportion distributed on the variable *Other* in the ICS compared to the SBS.

As mentioned above the estimated relative distribution for the *Other external expenses* in the ICS is not equal to the estimated distribution in the SBS for the same variable. Because of those measurement problems further studies must be carried out before decisions about how estimated populations total from the SBS should be used.

The cost distribution for small, medium and large sized enterprises in each sector has also been studied. No clear difference between the size groups was indicated, but of course, number of responding enterprises in each size group is small which means that substantial conclusions from this study is difficult to draw.

3.4. Conclusions and future plans

The use of income- and cost statements to get a good picture of what can be captured from the enterprises bookkeeping systems have proven to be successful. Along with the fact that references was made to the Swedish general chart of accounts (BAS) which is a commonly used by almost every small- and medium sized enterprises in Sweden. The possibility to send in income- and cost statements instead of filling in the questionnaire has also been successful in terms of response burden.

A general conclusion from the pilot survey is that collecting data on intermediate consumption for the these activities of the service sector is feasible. The use of SBS data is successful in terms of response burden since, by using this method, the samples can be kept fairly small. However, the relative estimated distributions differs between the two surveys so further studies are required.

4. Survey on intermediate consumption (ICS) 2006

4.1 Developing the survey for reference year 2006 on intermediate consumption

4.1.1 The use of SBS

For the survey of ICS for reference year 2006 the activities for motor vehicle trade (SIC 50), recreation, cultural and sport (SIC 92) and other services (SIC 93) were surveyed. A decision was made that the data collection should be done within the Structural Business Statistics (SBS) (described in 3.1.1). The three activities mentioned above almost only have costs for *Other external expenses* and therefore it was decided to extract the breakdown into the cost categories that national accounts needed.

The SBS produces separate estimates of the variables, *Expenses for raw material, Expenses for resale* and *Other external expenses* (divided into a large number of specified components see annex 2) based on information from all large enterprises complemented with information from small enterprises based on a sample survey.

4.1.2 Questionnaire design

It looks very different from sector to sector concerning how much that needs to be further specified. In some sectors there exist no *raw materials* at all whereas in other sectors there is a fairly large amount of *raw materials*. The three activities mentioned above almost only have costs for *Other external expenses* and therefore it was decided to extract the breakdown into the cost categories that national accounts needed. The key to a successful survey is the quality of the list of goods. Concerning *Other external expenses* from ICS survey for 2006 it was just a small share that was unspecified and left under the variable *Other*. This indicates that it was easy for the enterprise to fill in the questionnaire that was pre-printed in the ICS 2005 survey. A decision was therefore taken that same variables should be included in the SBS survey for the activities SIC 50, SIC 92 and SIC93. References to an in Sweden commonly used general chart of accounts (BAS) are pre-printed on the questionnaires in order to facilitate for the respondents.

For *raw materials* on the other hand the information could not be found in the income- and balance sheet statements and a decision was also taken that it was such a small share of the costs in these activities that we do not ask but the breakdown on productgroups.

4.1.3 Objectives of the pilot survey for intermediate consumption 2006

There were several objectives of the pilot survey:

- the possibility to collect the required information from the enterprises within the SBS
- see if the shares of *Other* under *Other external expenses* will decrease compared to SBS 2005
- get feed-back from the respondents on the questionnaire design
- to get a picture of how much costs the enterprises has for *raw materials*
- explore the structure of the expenses, is it similar for all enterprises in the same sector, is it the same for small and large enterprises
- estimate relative distributions and population totals of the specifications and give the National Accounts to explore.

4.1.4 Sample size within SBS

There are three different sample surveys in the SBS survey; one for turnover and costs, one for investments and one concerning stocks. Here the survey that concerns turnover and costs is discussed. The total sample size for survey on turnover and costs in the SBS are 14 000 enterprises.

For the activities that is covered by the ICS 1 381 enterprises are sampled. The sample for these activities is stratified by activity in 22 strata, see table 9. Within each strata a random sample is drawn where one enterprise has the including probability that is proportion to there size, i.e. a large enterprise have a larger probability to be sampled than a small enterprise. The stratification and sample size is as follows.

Table 9 Stratification and sample sizes

SIC 2002	Name	Sample size
50.101	Sale of lorries, trailers and semi-trailers	30
50.102	Sale of passenger motor vehicles	217
50.103	Sale of camping vehicles	42
50.201+ 50.203	Maintenance and repair of motor vehicles	73
50.202	Maintenance and repair of windows	80
50.204	Maintenance and repair of tires	36
50.301	Wholesale trade of motor vehicle parts and accessories	31
50.302	Retail trade of motor vehicle parts and accessories	66
50.4	Sale, maintenance and repair of motorcycles and related parts and accessories	84
50.5	Retail sale of automotive fuel	102
92.1-92.2	Motion picture and video activities; radio and television activities	105
92.3	Other entertainment activities	111
92.4	News agency activities	31

SIC 2002	Name	Sample size
92.5	Library, archives, museums and other cultural activities	27
92.6 excl 92.614, 92.7 excl 92.710	Sporting activities (except trot and gallop)	124
92.614	Sporting activities concerning trot and gallop	18
92.710	Gambling and betting activities	7
93.01	Washing and dry-cleaning of textile and fur products	28
93.02	Hairdressing and other beauty treatment	32
93.03	Funeral and related activities	36
93.04	Physical well-being activities	77
93.05	Other service activities n.e.c.	24
Total		1 381

4.2 Results from the pilot survey

Questionnaires were sent out to the enterprises included in the sample regarding for large enterprises in spring year 2007 and to medium and smaller enterprises in autumn 2007. Enterprises who did not return their questionnaire were reminded by postal mail and by telephone. When the data collection was finalized number of returned questionnaires were 1046 which means 75.7 % in terms of number of questionnaires, see table 10. SIC 92 have the largest respond rate with 78.5 per cent within SIC 93 the response rate was 74.1 per cent.

Table 10 Number of returned questionnaires

SIC 2002-Group	Number in sample	Number of Responses	Unweighted
50	761	568	74,6
92	423	332	78,5
93	197	146	74,1
Total	1 381	1 046	75,7

4.2.1 Conclusions from the pilot survey for ICS 2006 – when data was collected from SBS

The response rate is much higher when the data was collected in the SBS compared when the data was collected in an own survey for the reference year 2005. The response rate for 2006 was approximately 76 per cent compared to 56 per cent. The reason for the differences can be:

- the survey for 2006 was mandatory which it was not for reference year 2005
- there are different activities that is covered
- the SBS survey is a well known survey
- the SBS survey can spend more resources for the reminding and editing procedure
- the reminding procedure are different

Even if the response rate was a bit higher than expected some valuable results of the functioning of the questionnaire and the functioning of the data collection within the SBS could be derived. These results can clearly be seen in table 11. A rather high amount of *Other external expenses* are still found under *Other.* National accounts need information that is divided into well-defined product groups with a result of almost zero on other costs. In the ICS survey for 2005 there were less than 10 per cent left on other costs. In the activities that was surveyed 2006 there are still from 13 to 28 per cent that is unspecified.

Table 11 Proportion of Other in Other external expenses unspecified in the SBS and in the ICS

SIC-Group	Other external expenses Unspecified in SBS – 2005	Unspecified in SBS – 2006) ICS
50	35.0%	23.2 %
92	20.0%	12,9%
93	38.4%	27.6%

This indicates that the:

- pre-printed variables have not worked in a satisfying way. But the same pre-printed variables worked very satisfying in the ICS survey for 2006
- editing program did not work in a satisfying way in the SBS survey concerning the cost for intermediate consumption for the ICS activities
- questionnaires were not so well handled as it was when ICS was collected in an own survey for reference year 2005. For the reference year 2005 each questionnaire was treated manually and feedback was immediately taken with enterprises that has large values under *Other*
- more information is gathered with all the pre-printed variables than it was in the SBS survey for 2005

Concerning the information of raw material no information broken down on product groups was collected within the SBS survey for 2006. In table 12 the amount of the total costs that raw material stands for. These rather high amount of *the total costs* are still found under *Raw material* especially for *Maintenance and repair of motor vehicles (SIC 50.2)* and *Other service activities (SIC 93)* with 53 and 20 per cent respectively. National accounts need information that is divided into well-defined product groups with a result of almost zero on raw material.

Table 12 Proportion of Raw material compared to total costs in the SBS and in the ICS

SIC-Group	Raw material Unspecified in SBS -2005	Unspecified in SBS -2006 (ICS)	Value in SBS 2006 SEK million
50 excl 50.2	3.0 %	3.0 %	563
50.2	39.6 %	53.0 %	4 211
92	10.5 %	7.0 %	3 924
93	14.4 %	20.4 %	1 402

Which kind of costs that is hidden under *Raw material* is hard to know but some thoughts are given below that can be tested in the future:

- for *Maintenance and repair of motor vehicles (SIC 50.2)* the *Raw material* can be motor vehicle parts and accessories that is used for maintenance and repair of motor vehicles
- for *(SIC 50 excl 50.2)* the *Raw material* also is motor vehicle parts and accessories that is used for maintenance and repair of motor vehicles which also is done by this enterprises in some scale
- for *Other services (SIC 93)* the *Raw material* can be shampoo, hair jelly, spray, oils and similar things that is used by *hair dressers* and *physical well being* enterprises. It can also be flowers and related products that are costs in *funeral and related activities*

4.4. Conclusions and future plans

The inclusion of the ICS survey in the SBS survey gave different results. The response rate raised from for 56 per cent for reference year 2005 to 76 per cent for reference year 2006. The main reason for this is probably that the survey for 2006 was mandatory which it was not for 2005.

The costs which still are unspecified in SBS 2005 were higher than the one in SBS 2006 but it was still very high for the year 2006. The reason for this was probably due to that the editing controls did not work so well and not because of that the right variables was included in the questionnaire. The use of income- and cost statements to get a good picture of what can be captured from the enterprises bookkeeping systems did work well in ICS 2005. The possibility to send in income- and cost statements instead of filling in the questionnaire has also been successful in terms of response burden.

5. Plans for survey on intermediate consumption 2007

The ICS survey for the reference year 2007 will be a part of the SBS survey. The activities that will be surveyed are transport (SIC 60), computer services (SIC 72), business services (SIC 74) and sewage and refuse disposal, sanitation and similar activities (SIC 90). The costs for these activities where divided as follow of table 13 in the SBS survey for the reference year 2006.

Table 12 Division of costs

SIC	**Division of costs**				**Shares of costs**	
Group	Raw material and consultancy services	Other ext. costs external costs	Other of other	Total costs	Share of raw material comp. total costs	Share of other comp. other external costs
	in SBS – 2006	in SBS -2006	in SBS -2006	in SBS -2006	in SBS -2006	in SBS -2006
60	8 751	76 290	19 126	85 040	10.3%	25.1%
72	19 533	44 371	20 857	63 904	30.6%	47.0%
74 excl 74.1+74.4	27 759	42 389	22 977	70 148	39.6%	54.2%
90	2 902	6 147	2 669	9 049	32.1%	43.4%

In the table it can be seen that a rather large proportion of the costs were unspecified under *Other external costs.* The figure varies from 25 per cent for *land transport activities (SIC 60)* to 54 per cent for *business services (SIC 74).* Under Other external costs the same variables that were included in the SBS survey 2006 will be included for these activities in the SBS survey 2007. Even if the results was not so good in the SBS survey 2006 (a large portion was still unspecified) we think that the variables are the right one and that instead of including more variables we have to work more carefully with the returned questionnaires. In the editing program a control is included which says that all enterprises with more than five per cent has to give us feedback about the costs which are unspecified.

In the table it can also be seen that a rather large proportion of the costs come from *Raw material and consultancy services.* The figure varies from 10 per cent for *land transport activities (SIC 60)* to 40 per cent for *business services (SIC 74).* What is hidden under these costs has been discussed with branch organisations and people at Statistics Sweden which is branch experts. Income and cost statements that have been collected in the SBS survey for 2006 have been studied if it is possible to get any information from there. Information about which costs that the National accounts have in there supply and use tables and the imports from the foreign trade statistics has also been studied. From all these information draft questionnaires has been made. But still there seem to be very large gaps and lack of information about which costs that shall be pre printed in the questionnaire.

There also seem to be large measurement problems for these activities since a lot of the enterprises in there book keeping record costs under *Raw material* that other enterprises record under *Other external expenses.* A decision was therefore taken to make the collection of the *Raw materials* as a follow up of the SBS survey done as a telephone interview. Approximately 200 enterprises will be contacted by telephone and information for costs for *Raw materials* will be collected according to the draft questionnaire that been made. The telephone study will give us the following answer:

- Have the enterprise he possibility to provide us with detailed information for *Raw material*?
- Which costs do the enterprises have under *Raw material*?
- How has the costs worked that we have drafted on the questionnaire?
- Is there a difference between small and large enterprises within an activity for costs of *Raw material*?

Annex 1 – Draft over intermediate consumption in National accounts for Computer services activities (SIC 72)

Name	SIC for products (SPIN)	Value SEK million
Total		**63 780**
Data program	7220	11 764
Legal and accounting, bookkeeping and auditing services; tax consultancy	741	9 862
Letting of own property	7020A	5 000
Other computer services	72A	2 625
Publishing services	221	2 318
Other business services	748	1 993
Consumption abroad	99901	1 733
Architectural and engineering services and related technical consultancy	742	1 718
Printing and service related to printing	222	1 461
Advertising services	744	1 410
Telecommunications services	64201A	1 120
Adult and other education	804	1 095
Mobile telecommunications services	64201B	1 019
Labour recruitment and provision of personnel	745	957
Manufacture of plastic products	252	840
Restaurant services	55A	829
Treatment and coating of metals; general mechanical engineering	285	828
Hotel services	551	744
Banks and other financial institutes	65A	737
Post services	641	552
Manufacture of electrical equipment	316	533
Manufacture of cutlery, tools and general hardware	286	532
Manufacture of machine tools	2940	513
Research and development	73	431
Air transport services	62A	412
Construction	45	397
Manufacture of machinery for mining, quarrying and construction	29520	390
Activities of other transport agencies	63400	389

Annex 2 – Costs variables which is included in SBS 2006 (ICS)

Cost variables	**Cost variables**
Raw materials	Insurance and tax for cars
Raw materials excluding energy	Exchange rate differences
Energy costs	Costs for valuable document trade
Costs for fuel for energy and heating	Travel costs (tickets, cars, food and room)
Costs for electricity for lightning	*Ticket costs*
Costs for electricity for heating	*Car rent costs*
Costs for fuel for heating	*Food and room costs*
Costs for distant heating	*Other travel expenses*
Costs for food and drinks	Real estate tax
Costs for refining	Costs for rent of premises
Costs for goods for installation	Siteleasehold right
Other raw materials	Service and maintenance of premises, house and installations
Costs for construction services	Costs for data program
Costs for fuel	Management fees
Other costs for vehicles	Sales provisions
Office supply costs	Legal and accounting services
Incidental material	Costs for IT services
Water and sanitary costs	Bank costs
Other inventories with a life length longer than one year	Credit card costs
Other inventories with a life length less than one year	R & D costs
Costs for property and enterprise insurance	Economic consultancy services
Costs for hired transport with aeroplane	Business organisations costs
Costs for hired transport with train	Printing costs
Costs for hired transport by road	Costs for advertising and PR
Costs for hired bus transport	Costs for rented personnel
Costs for purchase of traffic	Other consultancy services
Costs for taxi transports	Costs for guard and alarm
Costs for transports with ship	Cleaning services
Costs for transport agent activities	Costs for radio and TV programmes
Costs for machine services	Costs for horse owners
Costs for rent of vehicles/machines without driver	Program costs
Other costs for freight and transports	Costs for gains for players
Costs courier services	Costs for contribution to associations
Postal services	Costs divided to central alliance and tracks
Tele and data communication costs	Costs for horse sports active
Reparation and services costs for machine and inventories	Representative provisions
Reparation and services costs for vehicles	Costs for announce
Costs for financial leasing	Costs for flowers and food
Other costs for rent and leasing of fixed assets	Costs for music and so on
Contribution accounted as cost reduction	Guarantee costs
Losses on short term claims	License costs and royalties
Insurance of vehicles	Restructuring costs
Insurance for goods transportation	Other costs

Measurements of ICT Investments/ expenditures within Statistics Sweden

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Introduction

In the year 2000, the Swedish government set up an investigation with the purpose of analysing and describing the changed needs of society's economic statistics. The focus was on the needs of the National Accounts. In January 2003, the results from the investigation were published (SOU 2002:118). In the investigation, one concluded that there was a need for an expansion of the ICT (Information and Communication Technologies) statistics in order to analyse the effects of the ICT on economic development. One saw a need for statistics on investments in hardware as well as software.

After that the report was published, Statistics Sweden started the EMMA project, aiming at improving those economical statistics focused on the National Accounts. One part of the EMMA project was to annually collect data on Enterprises' ICT expenditures. Since 2005, a survey is conducted annually by Statistics Sweden where the enterprises are asked about their expenditures on ICT.

This article aims primarily at describing the background and the development of the measurement tool of ICT investments/expenditures in enterprises within Statistics Sweden. Some results from the 2008 survey and plans for the future are also presented.

Background

National Accounts

In the Swedish National Accounts, intermediate consumption and gross fixed capital formation of ICT *hardware* products are estimated mainly with a supply based method. Production statistics as well as statistics regarding imports and exports of ICT products are considered reliable and determine the total supply of each product.

However, there is very little information regarding allocation of use between intermediate consumption (IC) and gross fixed capital formation (GFCF). There is also very little information regarding the structure of the use, e.g. each industry's share of the total IC or GFCF. Both of these weaknesses will hopefully be amended with the aid of the new survey.

Regarding purchased software, there is some information available regarding the structure of gross fixed capital formation, but very little information regarding the structure of IC, which the new survey hopefully will provide.

Regarding production and gross fixed capital formation in own-account software, a model based on a number of sources is used. Information regarding number of computer specialists and their salaries is provided by the Occupational register and Salary statistics. Information about the amount of time spent on software development is provided by the survey"ICT usage in Enterprises". In this survey, companies are asked to allocate time spent by computer specialists to three parts i) software development for own use, ii) software development for external sales and iii) maintenance, support and repairs.

Eurostat Pilot Action

In 2005 Eurostat launched a pilot action on measurement of ICT expenditure/ investment. This was the starting point for the development of the survey in Statistics Sweden.

The Pilot Action was initiated in order to develop a more targeted indicator on ICT expenditure/investment for the eEurope Action plan and (in the long run) productivity. The intention was to have a better Structural Indicator on ICT in the future and to provide source data to meet national accounts needs.

The main aim of this pilot action was to develop and test methods for measuring expenditure/ investment in ICT. The survey should test and collect data and report on problems encountered on the variables below.

1) *Expenditure on IT goods (hardware)*
2) *Investment in IT goods (hardware)*
3) *Expenditure on telecommunications goods*
4) *Investment in telecommunications goods*
5) *Expenditure on pre-packaged and customised software*
6) *Investment in pre-packaged and customised software*
7) *Expenditure on own-account software*
8) *Investment in own-account software*
9) *Expenditure on other ICT services* (outsourced services, as well as services related to maintenance of hardware and software, data entry, network security, website design and hosting etc.)
10) *Expenditure on leasing ICT goods and services* (payments for leased hardware and software)

Except for the above mentioned variables it was also optional to include variables about what business processes the ICT Investment/expenditure was aimed to support.

The pilot action was divided into three modules:

A1) Enterprise ICT investment/expenditure survey

A2) Expert interviews on factors affecting productivity

B) Public sector ICT investment/expenditure survey

Statistics Sweden did participate in all three modules but the focus in this paper is the enterprise survey.

The Pilot Study in Statistics Sweden was conducted in three steps:

Step1: Pre-study; 10 face-to-face interviews with ICT managers or accountants

Step 2: Postal survey sent to 40 enterprises

Step 3: Postal survey sent to 250 enterprises

The main aim of the pilot study was to get a better knowledge about the possibility for the enterprises to give high quality figures on requested variables and to develop a feasible questionnaire.

In order to facilitate the use of ICT statistics and to clarify the definitions, the OECD has made an ICT goods classification list. The recommendation from Eurostat was to follow the OECD classification. According to the list, ICT goods can be divided into; Telecommunications equipment, Computer and related equipment, Electronic components, Audio & Video equipment, and other ICT goods. Statistics Sweden did focus on the first two categories; Telecommunications equipment, Computer and related equipment when asking about IT and Telecommunication goods.

Several problems of greater and lesser importance were identified. One major problem was the difference between the definition of an Investment according to National Accounts and the accounting rules of the Swedish enterprises. Since the desired information from National Accounts is to have information about purchases with a lifetime of more than one year and a value of approximately EUR 500, an extra breakdown of the variables into short-term assets was added. In the bookkeeping of the enterprises short-term assets did consist of several types of goods and many enterprises found it very time consuming and difficult to specifically identify purchases of ICT-products.

Other problems were related to the split between the variables. Hardware often comes as a package where software and a service agreement (support for a few years and licences) are included in the price. It was often not possible for the enterprise to separate the software and service agreement from the total cost of the hardware. Another example is the split between IT-goods and telecommunications goods, where the technologies are increasingly integrated, as IP-telephony as one example.

There were also problems related to ICT-services for example, where telephone call charges were often distributed within the organization and not easily identified in the bookkeeping. It was also difficult to separate the cost for the telephone from the telephone calls. In many cases costs for telephone calls, data transmission, telephone- and internet –subscription(s) were not included at all in the figures we received.

A risk was also identified in that the ICT-manager would only give figures on ICT investments/expenditures that were related to the administration of the enterprise and not ICT hardware used in a factory or Infrastructure investments. There was also confusion about ICT being embedded in machines used in the production.

In the follow-up work after the second version of the questionnaire, some enterprises told us that they had difficulties in answering the questionnaire because they belong to a group of companies with IT as a shared service. The difficulties were even greater if it was enterprise group with globally shared ICT services. The users of the shared services often paid a standard cost to the IT provider and the respondent did not know how to report this in the questionnaire. The IT providers also had difficulties in knowing how to respond to the questionnaire. To address this problem, a question on whether the enterprise was a part of such a group of companies was added. Instructions on how to fill in the questionnaire when this was the case were also added as was a variable "payment for IT services to a company in the same group".

A variable related to internal costs for ICT services was also added in version two of the questionnaire, which was sent to 250 enterprises. Many companies have internal departments that provide ICT services or their own employees handling maintenance and support. We found it relevant to ask about these costs since they often represent a significant part of the IT budget. Without this information, comparisons of total ICT expenditures on micro-level are all the more difficult.

The response rate for the survey of 250 enterprises was 51%. Contacts were made with some of the non-respondent enterprises in order to get a better understanding about why they did not answer. The main reasons were lack of time and the questionnaire was too time-consuming. The survey was not mandatory and some of the enterprises also have also a policy of not answering voluntary questionnaires.

Development of the questionnaire

2006

In 2006, the first ordinary survey was carried out. The reference year was 2005.

Too meet the problems found in the pilot studies some changes were made in the questionnaire. Instead of separate questions about IT-goods and telecommunications goods, these two were combined into one variable. Since the split of IT and telecommunications goods was still required for National Accounts a question was asked about an approximate percentage for IT and Telecommunications, respectively.

Instead of asking about short-term assets the enterprises were asked to estimate the part of direct expenses that had a life cycle of at least one year.

Also costs related to data and telecommunications services such as call charges, data transmission and internet subscriptions were extracted from expenditures on other IT services and put into a separate question in order to make sure the costs were included.

The response rate this year was very low, 39%. Apart from the questions on ICT, there were also questions added about personnel skills and organisational changes as commissioned by the Riksbanken. This increased number of variables might also have contributed to the low response rate.

Still it turned out to be difficult to ask the enterprises to estimate what percentage of IT hardware and of software that had a life cycle of more than one year. The enterprises stated that they had to look at specific invoices in order to find the information.

2007

In 2007, the second ordinary survey was made. The reference year was 2006. In order to reduce the response burden and increase the quality of the statistics, questions on personnel skills and organisation were removed. For the same reasons, the questions where the enterprises were asked to estimate what percentage of IT hardware and of software that had a life cycle over a year were removed. Further, after consulting the National Accounts, the question on own-account software was removed from this survey. As was the case earlier, the information will instead be captured in the survey on Enterprises' ICT usage by asking about numbers of computer specialists. For IT services, only one question was kept where the Enterprises were asked about expenditures for IT services divided by external and internal suppliers.

The question about internal costs for IT services was removed. The response rate increased somewhat, but remained at a low level, 53%. The questionnaire was still voluntary and the quality of results was still not good enough for publishing.

2008

Until today's date, the latest version of the questionnaire is from 2008 with 2007 as reference year. The government's requirement to reduce the response burden led to the removal of the questions about expenditures for data and telecommunications and the questions on IT services. Questions on cost-accounted expenditures and investments in hardware and software remained in the questionnaire. (See annex for the complete questionnaire)

The 2008 survey

In the beginning of 2008, a decision was made by the Director-General at Statistics Sweden that the survey was to be part of the official statistics. That the survey is part of the official statistics imparts the legal obligation for respondents to provide information.

A minimum of variables needed by National Accounts remained in the survey. The questionnaire was sent out as a postal survey addressed to the chief accountant in those cases where there was no name from the previous survey. Two reminders were sent out and one "thank you and don't forget letter". The data collection was started in the beginning of April and was terminated in July. At the end of this period, enterprises in strata with low response rates and enterprises within strata expected to have high investments rates were reminded by telephone. The enterprises were given the opportunity to answer either by post or electronically over the computer.

The fact that the survey is mandatory and that the amount of variables were reduced, helped increase the response rate. This year's survey had a response rate of 82%, which has to be considered a good result taking today's tendencies for decreasing response rates into account.

Results

The first results from this survey were published in October 7, 2008 on www.scb.se/NV0802. The results will also be presented in a publication (Företagens användning av IT) in late December 2008. Below please find a brief description of the methodology, the quality and a few results.

Methodology

In order to estimate the totals, the Horwitz-Thompson estimator is used:

$\hat{Y}_{HT} = \sum_{strata} d_k y_k$, where $d_k = 1/\pi_k$ and π_k equals the inclusion probability.

When the Horwitz-Thompson estimator is being used, straight expansion within strata is done. Extreme values have been put in their own strata with a weight equal to one.

The quality of the Results

ICT has had a fast growth and is today an integrated part of many products. This implies difficulties when deciding what should and should not be included. Limitations between different ICT products also are unclear. Experiences from the survey show that it is often hard to distinguish software from hardware and expenditures on telecommunications from the actual equipment.

With a sample survey comes some degree of uncertainty since not all elements in the population have contributed to the estimated values. Further, since the response rate was 82 % and not 100% another source for bias is introduced into the survey. In order to give a picture of the quality of the survey, the number of responses, number in the sample, number of the population and response rates per study domain are shown below.

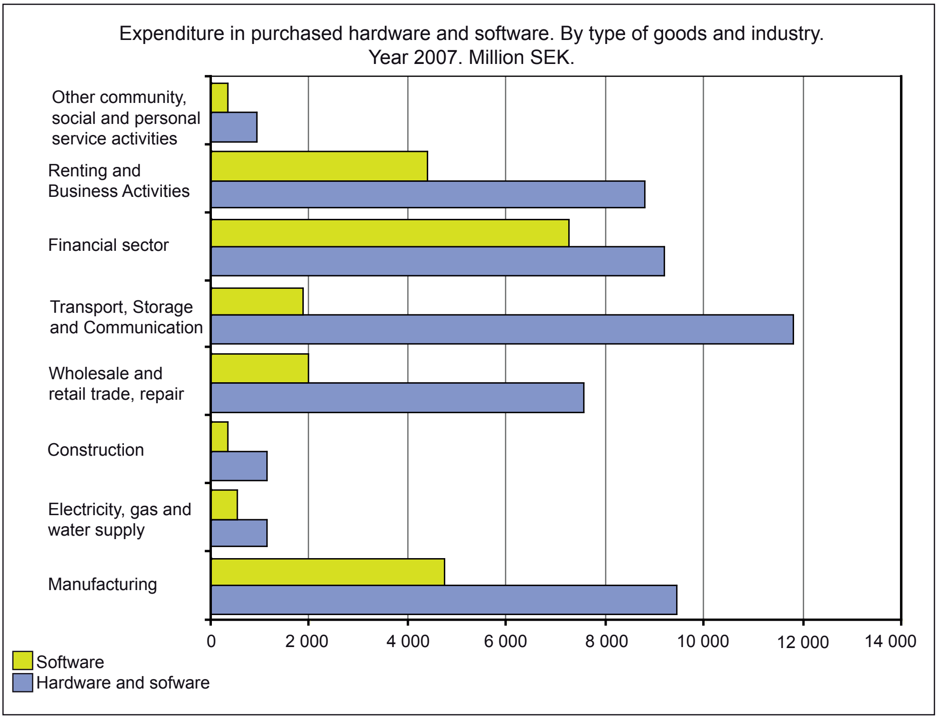
Regarding the population please be aware that the limit concerning number of employees differs between different industries. The lowest cut off is in NACE 40-41 where the sample includes enterprises with 5 employees or more. In NACE 10-37 the cut off is 50 employees or more.

NACE	Industry	Responses	Sample	Population	Response rate %
10-14	Mining and quarrying	10	12	12	83
15-37	Manufacturing	752	865	1854	87
40-41	Electricity, gas and water supply	90	97	284	93
45	Construction	193	249	1649	78
50-52	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods	733	941	7908	78
55	Hotels and restaurants	90	127	871	71
60-64	Transport, storage and communication	366	461	2686	79
65-67	Financial sector	192	205	278	94
71-74	Renting and business activities	1016	1233	5446	82
90,92-93	Other community, social and personal service activities	139	159	380	88
Size-categories					
5/10-49 employees	All industries	1420	1823	16120	78
50-249 employees	All industries	1361	1616	4338	84
250 employees or more	All industries	800	910	910	88
Total	**All industries**	**3584**	**4349**	**21368**	**82**

Table 1. Population and response rate 2007

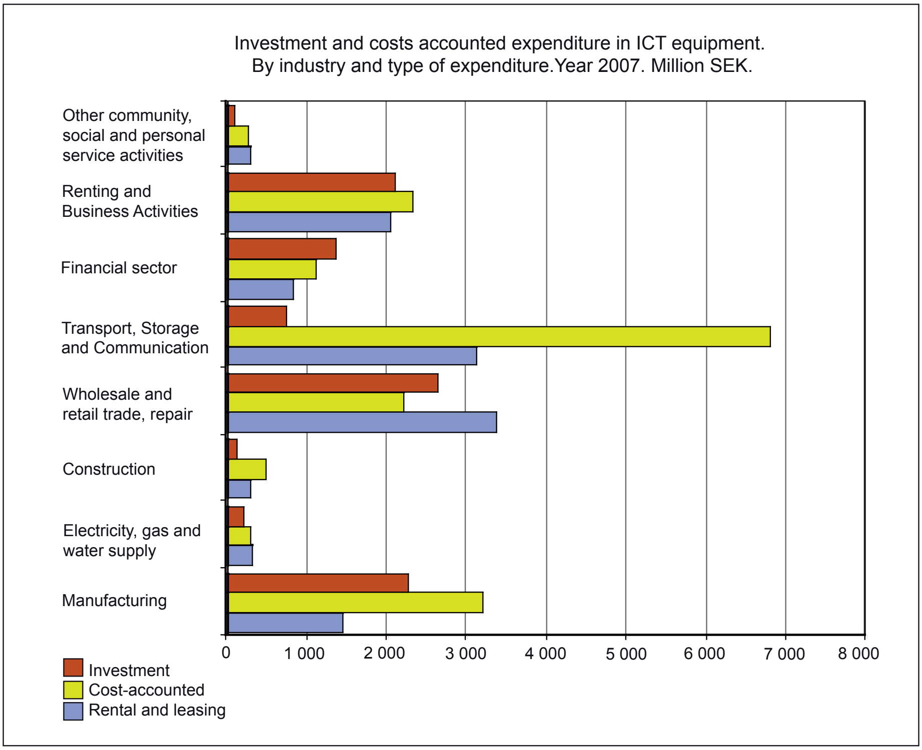
Results

Graph 1 below shows expenditure in purchased hardware and software by industry. The green bar shows only the software expenditures whereas the red bar shows the total expenditures in hardware and software. For example were the expenditures in the financial sector to a very high degree related to software purchases, whereas in the sector Transport, Storage and Communication the expenditures were mainly in hardware.



Graph 1. Expenditure in purchased hardware and software 2007

Graph 2 below shows the expenditure on ICT equipment by industry and type of expenditure. The red bar shows leasing costs, the green bars shows cost-accounted purchases and finally the blue bar shows investments in hardware included in the balance sheet. When comparing these bars please be aware of the differences between investments and leasing costs. In the investment figure the complete value of the good is included whereas in the leasing costs only the payment for one year, not the total value of the good, is included. The graph shows for example that in the financial sector the expenditures are to a large extent related to leasing costs. In the sector Transport, Storage and Communication leasing costs are relatively small.



Graph 2. Investment and cost accounted expenditures in ICT equipment 2007

Future plans for development

The survey is planned to be EU regulated in 2010. The variables to be included in the regulation are not yet fully defined.

An early proposal from Eursostat was to have a split in the questionnaire by IT goods, Telecommunications goods and other ICT goods. Other ICT goods would then contain electronic components and audio & video equipment. [1] Eurostat has also proposed that ICT services should be included. Hence, they might again come to be included in the survey.

The inclusion of other ICT goods with electronic components and Audio & Video equipment may complicate the future survey. In order to find out the capability of enterprises to accomplish the new needs of information Statistics Sweden subjected a chartered accountant as well as some enterprises with the

1 *The OECD list is being revised and the categories renamed, but the goods we are referring to is still included*

new variables. The answers were not encouraging from either part. Electronic components are to a large extent embedded in computers and related equipment and not bought separately. Therefore they would not be specified in the accounts. The variable is not relevant for a major of the Swedish enterprises. Also Audio and Video equipment is difficult to disclose in the accounts.

From a NA perspective, the results from the 2008 survey now needs to be analysed and compared to what is currently in the NA estimates, both regarding product allocation and industry structure. Future revisions of structures and allocation of ICT products to intermediate consumption and gross fixed capital formation could be a consequence when the results of the survey are implemented.

Annex 1 Questionnaire 2008

Information submitted here is confidential according to Chapter 9 § 4 of the Secrecy Act (SFS 1980:100)
The legal obligation to provide information is in accordance with the Law on official statistics (SFS 2001:99)
The Board of Swedish Industry and Commerce for Better Regulation has been consulted.

Enterprises' IT expenditure 2007

You can also submit information on the Internet **www.insamling.scb.se**
Use the following codes to log in:

UserID

Password

What should you include?
In this questionnaire, you should provide information on your enterprise's expenditures on IT and telecommunications. Expenditures can be divided into investments and cost-accounted expenditures. Please include all IT and telecommunication that support the enterprise's activities, regardless of whether used in administration, production or development work.

Information provided should only relate to the enterprise with the name and corporate registration number shown in the address box above. Do not include other enterprises that are part of a group of companies and only include activities relating to Sweden.

What should you not include?
Do not include software and specific hardware that are an integrated part of machinery, vehicles or similar. Do not include expenditure on equipment/software that will be sold on directly in an unchanged state.

Do not include depreciation or advance payments.

How to fill in the questionnaire
All amounts should be given exclusive of deductible value added tax.

NB! Write "0" if the answer to the question is zero.

Figures do not need to be exact – well-calculated estimates are also acceptable. Responses should be given in SEK thousands, e.g. 2 million (2 000 000) is written 2 000.

A Background questions

1 Reference period
The survey refers to the period from 1 January to 31 December 2007. If your fiscal year refers to another period, please state this period here.

Year Month Day – Year Month Day

2 Is the enterprises part of a group of companies?

☐ Yes

☐ No → *Go to question 4*

3 Which alternative(s) best describes your enterprise?

☐ The enterprise supplies other companies in the group with IT resources (1)

☐ The enterprises buys/uses joint IT resources provided by another company within the group (2)

☐ The enterprise does not use any joint IT resources

(1) *Expenditures that the enterprise has had for joint IT systems, maintenance, communication systems, etc. within the group of companies should be reported in the questionnaire. Equipment that is invoiced directly to another company within the group should not be included.*

(2) *Charges paid to a joint IT unit within the group of companies or parent company for common IT systems, service, maintenance, etc. should not be reported in the questionnaire.*

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Telephone: 08-506 940 50
E-mail: itutgifter@scb.se

Read this before answering the rest of the questionnaire!

Expenditure for purchase of software should be included in section *C, Purchase of software*. If software is included in the purchased hardware and it is not possible to separate this item, the cost of hardware including the software should be given in section B, *IT and telecommunications equipment*.

Expenditures for service, repairs and maintenance of equipment for IT and telecommunications should not be included in the questionnaire. If it is not possible to separate these expenditures from the expenditures for equipment, they should be included in section B, *IT and telecommunications equipment*.

Expenditures for the purchase of mobile telephones can be included in section B, *IT and telecommunications equipment*. If it is not possible to separate subscription fees from call costs for mobile telephones, then all such costs shall be excluded.

B IT and telecommunications equipment

Expenditures for individual hardware components and installation costs should be included here. Include expenditures for the IT and telecommunications infrastructure, i.e. the mobile telephone network (GSM, 3G/UMTS), fixed telephone network or broadband structure (local or national infrastructure for the Internet). Do not include expenditures for employees' home computers. If the enterprise provides or uses jointly available IT resources, see notes 1 and 2 under question A3 on page 1.

4 Please state the enterprise's expenditure in 2007 on purchased IT and telecommunications equipment. ❸

SEK thousands

a) Investments, i.e. included in the balance sheet . . . . [ ]

b) Cost-accounted expenditures, i.e. included in the profit and loss statement (excl. rent and leasing) . . . . [ ]

❸ *IT and telecommunications equipment, e.g.:*
– computer regardless of size, e.g. handheld devices, PCs, servers and larger systems
– keyboards, photocopying machines, printers and scanners
– network equipment such as routers and cable
– hardware firewalls
– telephone exchanges, telephones including mobile telephones, answering machines and telefaxes
– antennae
– burglar and fire alarms

5 Approximately how much of the total expenditures in question 4 relate to ...

Percent, approx.

a) ... computer equipment? ❹ . . . . [ ] %

b) ... equipment for telecommunications? ❺ . . . . [ ] %

Total expenditures for computer and telecommunications equipment . . . . 1 0 0 %

❹ *Example: computers, servers, hardware firewalls and photocopying machines.*

❺ *Example: telephone exchanges, telephones, incl. mobile telephones, answering machines, telefaxes, antennae, burglar and fire alarms*

6 Please state the enterprise's expenditure in 2007 on rental and leasing of...

SEK thousands

a) ... computer equipment, including any service . . . . . . [ ]

b) ... equipment for telecommunications, including any service . . . . [ ]

C Purchase of software

7 Please state the enterprise's expenditure on purchased software in 2007. (6)

Include expenditures for licenses and user rights for software.

SEK thousands

a) Investments, i.e. included in balance sheet . . . . . [ ]

b) Cost-accounted expenditure, i.e. included in the profit and loss statement . . . . [ ]

(6) ***Purchased software** can include*
– purchased standard software or
– software specially developed for your enterprise's needs by an external supplier.*

* *Include development work, from specification to testing. Also include further development work but do not include systems management. Do **not** include the enterprise's work to define requirements or training for staff that use the system.*

D Time spent and comments

8 How long did it take to find the requested information and answer the questionnaire? [ ] minutes

Please write any comments about the questionnaire or about your answers!

[ ]

E Contact person in the company

Name (IN BLOCK LETTERS)	Telephone (incl. code)	Mobile
E-mail		

Thank you for your cooperation!

Time series in the Swedish national accounts

Ann-Marie Bråthén, Statistics Sweden

Present situation

At present the fully developed national accounts (NA) series start 1993. The Swedish NA comprises consistent series of GDP calculations from production and expenditure side (Goods and Services accounts) as well as Sector accounts. The accounts are annual and quarterly. Annual accounts are more detailed than quarterly accounts. Annual calculations of Goods and Services accounts are carried out in a system of supply and use tables. Sector accounts include the Primary and Secondary distribution of income and Use of income accounts, as well as the Capital account including the Financial account. The Other changes in assets accounts and Balance sheets are not fully compiled at the moment.

The Swedish NA follows the recommendations of SNA93/ ESA95. The first SNA93 accounts were published in first half of 1999.

At that time the time series comprised the period 1993 – 1998, six years or 24 quarters. That must be considered a short NA time series and of course users complained and asked for longer series. In answer to that series back to 1980 were published by the beginning of year 2000. These series were considerably less detailed than the full accounts from 1993, less detailed regarding variables and more aggregated concerning activities, purposes etc. Furthermore it was just calculation the Goods and Services account, with supporting data on employment, there was no sector accounts.

In the new calculations from 1994 constant prices are calculated with t-1 as base year (chain index) and presented with a fixed reference year, presently with year 2000 as reference year. The series 1980 -1993 are calculated with fixed base years. Constant price series the period 1981-1985 has base year 1980, 1986 to 1991 base year is 1985 and for1992-1993 the base year is 1991. However the whole period is chained to and presented in reference year 2000.

Sector accounts for all sectors have never been compiled after the implementation of SNA 93. Accounts for Government sector only, 1980 to 1992, was published some years ago, but are not updated after the latest revisions.

Older series

SCB took over the responsibility for compilation of NA from the National Institute of Economic Research (KI) in the beginning of the 1960th. At that time NA series comprised the period from 1950 and onwards. NA broadly consisted of calculations of GDP from production and expenditure sides (with a certain degree of details), and sector accounts.

NA has developed considerably since that time. For example international recommendations have been revised and developed more than one time, scope and definitions have been changed, classifications have been changed and new classifications have been introduced. Input-Output tables have been added, quarterly accounts have been introduced, capital stocks have been calculated, among other things. Data sources for NA has also developed and undergone considerable modifications. Methods for constant price calculations have been changed and different base years have been used.

SCB is responsible for NA time series from 1950

In principle SCB:s responsibility for "modern" NA series covers the period from 1950 and onwards. The policy during the years has been to keep complete, consistent time series for a certain, reasonably long period of time. According as new tables, recommendations, classifications, sources etc were introduced, and the longer the time series grew, it was not longer considered feasible, or possible considering the resources needed, to continue to update the full set of accounts for the whole time period. On the contrary, the lack of information concerning earlier periods when new concepts have been brought in, has been an obstacle, and rather than to make guesstimates that might obscure the data it has been considered better to take breaks in the time series. In general there are major breaks in the series, 1963, 1980 and 1993. There are also some breaks 1970.

In order to meet user's demand for longer coherent time series an aggregated table on GDP by expenditures has been back casted to 1950, at current and constant (reference year) prices. Linking has been carried out using the growth rate for each aggregate (consumption, capital formation etc) from earlier versions, including the growth rate for GDP. The idea behind using this method is the assumption that the earlier estimates give the most "true" picture of the growth, even on the most aggregated (GDP) level. Back casting of GDP components at the aggregated level and summarizing to GDP is considered giving a more questionable result. The setback of using the method is that it results in series that are non additive.

There are of course many other problems with such a method, for example there is an obvious risk that new phenomena, as the introduction of new technical equipment, will be back cast to far back in history.

"New" time series 1980–1992

It seems as if user demands of long time series are growing over time. Many users ask for more detailed data at least back to 1980 and even data from 1970 and onwards are sometimes asked for. Therefore there is a project aiming at (re)constructing NA-tables 1980-1992 that are consistent with the current NA 1993- onwards.

The level of details will be considerably higher than the current back cast series. At present production accounts series comprises Values added for eleven activities, the "new" estimates will in addition present Gross output and Intermediate consumption data, and on a 2-digit NACE level (appr. 50 activities).

Household consumption will be calculated on 3-digit COICOP (compared to nine durability groups) and Fixed capital formation will be presented by activity and by type of asset. Also Government consumption will be calculated with more details.

Constant prices will be calculated with annual chain index. Production side and expenditure will be balanced, although not in a system of Supply and Use tables, and series will be additive. Later, sector accounts consistent with GDP calculation will be constructed.

Problems and possibilities

This may not seem to be a very big, or difficult, task. But in fact it is. The first question is, why does the present SNA93 accounts start in 1993 would it not have been better to construct the longer series when the change over from SNA68 was done. Of course it would have been better, but at that time in the mid-90th, the resources for statistics in general and thereby for national accounts were very strained. Many changes had occurred. Major changes in the statistical system were introduced in the beginning of the 90th. Many changes were to the better, but even so they implied breaks in the statistical sources for NA. A new industrial classification SNI 92 (based on Nace rev.1) was introduced in 1993. Furthermore SCB was in the process of changing IT platform, which took a lot of resources.

However, the major change was the shift from SNA68 to SNA93. New concepts and definitions, or classifications, were introduced and sources concerning earlier periods were not always available.

All this taken together it was not, at the time, possible to assign resources for calculation of longer time series.

So what is the situation now, has it become more easy to compile data for earlier periods, of reasonable quality? Are there new or developed sources? Are more resources available?

The answers are mostly no.

- Of course it is more difficult to find information for earlier years.
- The problem with changes of classifications remains,
- It is difficult to find detailed information on transactions that have been reclassified or revised.
- Old computer files are not any more available, or very difficult to obtain data from.
- Changes in models are not fully documented or documentation exists but is scattered and difficult to find.
- At present financial resources are available, human resources for the job are more scarce.

The crucial question is of course, what is"reasonable quality". It seems as if (some) users merely ask for figures and don't care too much about information. National accountants on the hand might aim too high, and demand higher quality than what is needed.

General methodology

One conclusion that can be drawn of the work carried out so far is that it is not as simple as just to make simple"back-casting" of current series with old growth rates. For one thing it is not so easy to identify suitable old series that are representative. On the other hand it is not possible to make complete detailed calculations, that is too resource demanding and to data demanding. So it is necessary to find some kind of compromise. A specific problem is that since the first publication of SNA93 accounts NA has undergone at least three revisions, all three of them depending of, or including, rather substantial changes of definitions, but also revisions caused by changes of sources. All these changes have to be taken into account in the update of series before 1993.

Questions

Is it acceptable to get a (somewhat) new picture of the 1980th economy? Not only partly revised but also changes in the GDP growth rate?

Is it acceptable to present a stepwise revision, with some parts published first and other parts later? Or is it better to delay publication until all parts are finished?

(Example: First publish GDP calculations, (production and expenditure) and publish employment figures later.)

Lessons for the future

Any time a revision of time series, may it be because of new classifications being introduced, or revisions in concepts (manuals), or pure data revisions, is carried out, try *always to keep long time series.* National Accountants tend to think that it is better to keep original series rather than making more or less model based recalculations, but experiences show that users urgently demand both. And it is not easier to make the recalculations later.

This is something to bear in mind, just now, when plans are made up for the coming introduction of the new industrial classification SNI2007.

Measuring prices for ICT goods and services in Sweden‡

Olle Grünewald and Ulf Johansson**, Statistics Sweden*

Abstract

One of the main challenges in measuring prices over time is how to adjust for changes in quality. ICT goods and services change frequently and make great demands upon the methods used. In this paper we describe how ICT goods and services are measured in the Swedish price indices. The methods being used to measure prices for goods differ between the indices. This is however not regarded as a problem since the price development is similar. Some methods for measuring prices for services fail to take into account changes in productivity which could lead to incorrect indices over time.

Introduction

Price indices are primarily used as a measurement of inflation or as deflators for real measurements in the national accounts. Errors in the measurements of inflation could e.g. affect the central bank's decision on how to adjust the interest rate. Inaccuracies in the deflators cause corresponding errors in the real measurements of the national accounts. Thus, the quality of the price indices affects the quality of the output from the national accounts and by that also the productivity measurements.

‡ *A previous version of this paper was presented at the Productivity and ICT Conference, 23 October 2008, Stockholm, Sweden. The authors would like to thank seminar participants and in particular Jan de Haan for valuable comments and suggestions. The views expressed are those of the authors' and do not necessarily reflect the policies of Statistics Sweden or the views of other staff members.*
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** *Price Statistics, Statistics Sweden.*

One of the greatest challenges in calculating price indices is to separate quality changes from changes in price. This is particularly relevant for high-technology goods and rapidly changing markets. The goods and services produced in the information and communication technology (ICT) sector are constantly changing by incorporating new technology, enabling the quality of the goods and services to increase. Hence, capturing the change in quality is the key factor in measuring prices in the ICT sector.

The process by which the quality of a good or service is adjusted over time is called quality adjustment. For example, computers have been measured in some of our indices for a long time. When old computers are substituted for new computers, the performance has probably changed, for example: larger hard drive, faster CPU etc. This implies that in order to compare the new computer with the old, the base price has to be adjusted. The base price is based on the old computer and has to be adjusted by the difference in quality between the old and the new computer.

In this paper we will look at some of the core goods and services in the ICT sector, how they are measured and the problems and challenges in measuring the products. The goods and services we have chosen to present in this paper are: computers, cellular phones, services and goods in various parts of telecommunications and computer consultancy services.

The paper is organized as follows: section 2 presents ICT goods, section 3 presents ICT services and finally section 4 gives the concluding remarks for the paper.

ICT goods

Computers

Prices for computers are measured in the Import Price Index (MPI) and in the Consumer Price Index (CPI). The most common methods for measuring computers are the Hedonic method and Monthly Chaining and Resampling (MCR). Empirically the two methods do not give the same results but rather have shown to differ (Triplett, 2004, chapter 4). In the Swedish indices both these methods are used. For imported computers an indirect hedonic method is used whereas MCR is used in the CPI. The choice between the two methods has been a matter of both the tradeoff between quality and resources and based on studies made at the unit of Price Statistics at Statistics Sweden.

Imported computers

Two price indices for computers are calculated in the MPI, one for desktop PCs and one for laptop computers. Both indices are calculated as geometric means of desktop PCs and laptop computers respectively. The geometric mean consists of the individual price development for each computer being calculated as a Jevons index with the base period in December the previous year. Quality adjustment for computers is made with an indirect hedonic method. This methodology has been used for imported computers since the early 1990s and implies that two regression models are estimated, one for desktop PCs and one for laptops, where the values of the parameters are used to calculate a quota adjusting the base price of the computer being measured. Thus, when a computer no longer is representative for a company's import, the indirect hedonic method is used to make the two computers comparable. The assumption behind the method is based on the price of the product being dependent on a number of characteristics which is a function explaining the expected price of the product.

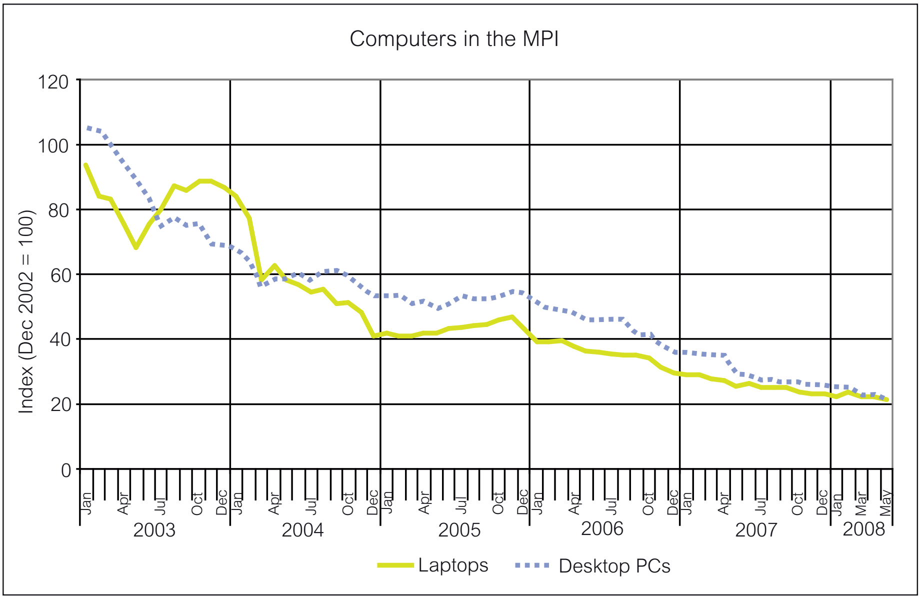
Since 2006 the sample for the estimation has been around 100 observations for each regression taken from price comparison sites on the Internet. Consequently, the observations that the regressions are built upon are taken from the consumer market and not the import market. The reason for this is twofold: first, import prices in large quantities are hard to get and second, the relative relationship between computers is assumed to be identical for the import line and the consumer line. Prior to 2006 the sample was taken from previous observations two years back in time adjusting the price with a time dummy variable in order to create observations. Further, only one regression was estimated using a dummy to separate for desktop PCs and laptop computers. Since 2006, double logarithmic functions were used for desktop PCs and laptops up till 2008 when this was changed for desktop PCs in favour of a linear model. The linear model for the desktop PCs produced better results in tests of the functional form compared to the double logarithmic function[1]. The functional form used to estimate the regression models also varies among countries, e.g. the Bureau of Labor Statistics uses a linear function in the PPI[2] whereas other countries uses double logarithmic functions.[3]

1 *The methodology used in determining the functional form and the variables to be included in the final model was done by using the LSE methodology, compensating for mass significance with misspecification tests and using various information criteria. In large, the methodology was taken from Verbeek (2004) chapter 3 and Kennedy (2004) chapter 5.*

2 *For a description of the method used by the BLS see Holdway (2001).*

3 *For an discussion of functional forms in hedonic regression, see Triplett (2004) p. 180-189.*

Figure 1



Source: Statistics Sweden

In the figure above the price development for computers between 2003 and 2008 is shown. In general the prices for the two types of computers follow each other closely except for the large oscillation for laptop computers in 2003. During the whole period a computer bought in December 2002 has approximately 20 percent of its value left in May 2008. However, some areas of problems are worth highlighting. Transfer prices are accepted in the Swedish price indices which might cause changes in prices which are not comprehendible with market fluctuations. Further, it is problematic that the regression models are not based on prices from imported computers.

Computers in the CPI

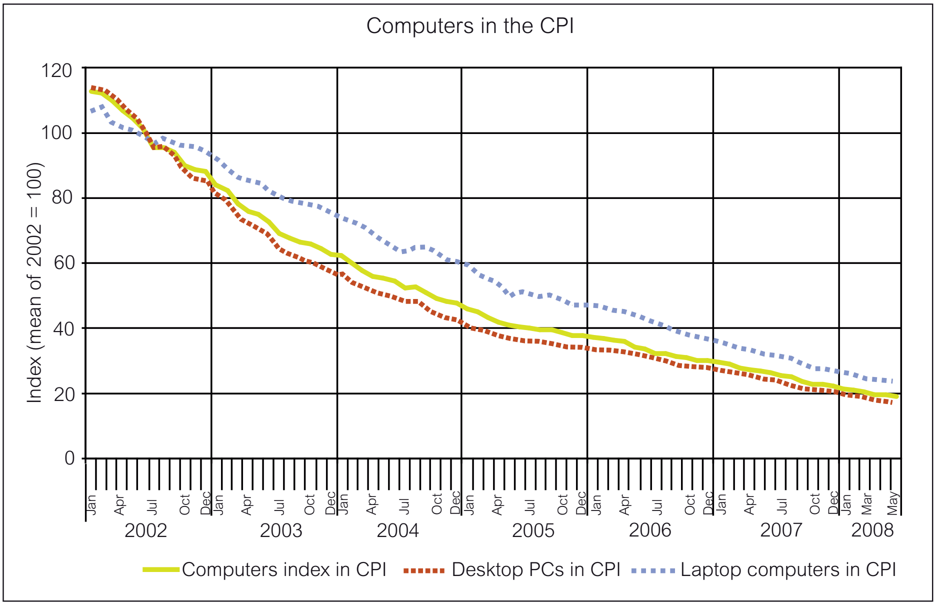
Computers are also measured in the Consumer Price index (CPI). The current method is a version of the MCR method. MCR is a variant of the overlap method but instead of following only one representative good, a sample is drawn each month and only those observations that are contained in both the previous and the current sample are included in the calculations. The items drawn in the sample for the base period are kept in the calculations throughout their lifetime. In the CPI the resampling is thus exchanged for a constant sample. The sample for computers consists of prices from both retail and the Internet. Price collectors choose representative computers at the retail and statisticians choose computers from the Internet. As for the imported computers, indices for desktop

PCs and laptop computers are calculated separately. For each computer the same model is measured from month to month until it is no longer representative. The intersection of the computer models in the sample in two adjacent months is included in the calculations. The equation used to calculate the short term link is given below:

$$I_{t-1}^{t} = I_{t-2}^{t-1} \prod_{i=1}^{n} \left(\frac{p_{i,t}}{p_{i,t-1}} \right)^{\frac{1}{n}} \qquad \mathbf{1}$$

where in this case $i \in \Omega_t \cap \Omega_{t-1}$ where Ω_t is the set of observations at time t i.e. computer model i has to belong to the set of computers that are contained in the sample at period t and t-1. Thus the size of the sample is constant over the year but the number of matches varies from month to month. The same method is used for computer accessories (screens, routers and printers) but the life length is much longer for the accessories compared with computers. The method is based on the assumption that the price changes of the observations that are matched in the model are equal to the price change of the unmatched observations (Ahnert and Kenny, 2004).

Figure 2



Source: Statistics Sweden

In the figure above the price trend for computers is presented. The methodology above has been used throughout the whole period. In contrast to the development for imported computers, both the desktop PCs and laptops have a smoother trend. The computer index in the CPI is a weighted index combined with the two types of computers. The series for desktop PCs is closer to the computer index because desktops had a heavier weight up until 2008. In the beginning of the period the figures are based on a rather limited number of price observations. However, the number of observations increases over the years. As for imported computers some problem areas are worth highlighting. Measuring the computer until it is no longer sold might not be optimal since the last part of the computers life cycle is generally not representative for the price trend of computers and could cause a downward bias. Comparing the development for imported computers and computers sold on the consumer market, we can conclude that the decline in prices is approximately the same for both markets. Possibly this implies that the downward bias measuring computers as in the CPI does not affect the price trend notably. Further, when a computer is no longer representative a replacement is chosen on the same premise as its predecessor. However, the distribution of brands is not guaranteed to reflect the market using this method, since the computers are chosen by the statistician or price collector and not according to sales data for instance.

A hedonic method has been considered to be implemented for computers in the CPI, but previous studies at Statistics Sweden have concluded that the current method is sufficient enough (Ribe, 1998). There is an ongoing discussion on implementing hedonics for computers in the CPI.

Cellular phones

Cellular phones are measured in the MPI and the CPI. This is a product that changes very frequently and is particularly difficult to measure over time since new functions are added to the phones such as cameras, GPS, Internet etc.

Cellular phones in the MPI

We start by looking at how cellular phones are measured in the MPI. Up until 2006 a conventional methodology was used, i.e. the measurements were based on representative goods and the main quality adjustment method was the overlap method. This method, also described above, is based on the law of one price, i.e. the difference in quality between the old and the new product is then assumed to be equal to the difference in price between the two products. A study conducted at Statistics Sweden by Deremar and Kullendorff (2006) concluded that due to price skimming[4] and the rapidly changing cellular phone market, the difference in price does not imply the same difference in quality. Using the overlap method when adjusting for quality changes and using the traditional run-up when measuring these goods is not favourable in the case for imported cellular phones. In 2006 MCR was implemented instead. In the Swedish MPI a modified version of MCR

4 Price skimming is when the seller takes advantage of the inelastic demand in the beginning of a products life cycle and sets a relatively high price at first in order to lower the price over time.

is applied. The companies in the sample and the weights for the companies are constant over the year and the resampling is done within every company, i.e. the company is asked to report e.g. the eight most popular cellular phones imported last month. For each company a Walsh index is calculated:

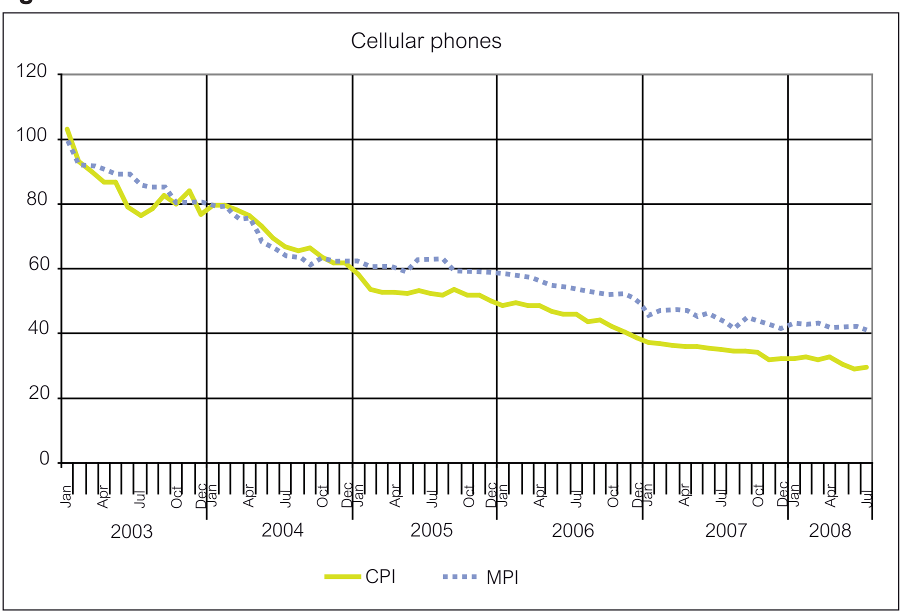
$$I_{t-1}^{t} = I_{t-2}^{t-1} \frac{\sum_{i=1}^{n} p_i^t \sqrt{q_i^{t-1} q_i^t}}{\sum_{i=1}^{n} p_i^{t-1} \sqrt{q_i^{t-1} q_i^t}} \qquad 2$$

where i is the model for the cellular phone, p is the price of the phone and q is the quantity imported. In order to calculate the weights for the different cellular phone models within each company, the quantity and price of the respective model is multiplied.

Cellular phones in the CPI

Cellular phones are measured in the CPI in the same way as computers, i.e. a modified version of the MCR. The method was introduced in 2004. Prior to the current method, only retail prices were collected. Quality adjustment was done by the price collector when the particular cellular phone was no longer for sale. This caused an uncertainty in the accuracy of the quality adjustments being done. Today, prices are collected in the same way as computers but list prices are also collected. Prices including and excluding subscriptions are collected but the cost of the subscriptions are omitted.

Figure 3



Source: Statistics Sweden

In the figure above we show how the prices in the MPI and the CPI for cellular phones have developed since 2003[5]. Both indices have a decreasing trend and they follow each other rather closely over the whole period. Over the period, a cellular phone on the consumer market costs only a third compared with the base period in December 2002, whereas for imported cellular phones the decrease is slightly less and the price for imported cellular phones are about two-fifths of the base price. One reason behind the differences between the two indices could be the acceptance of transfer prices in the MPI and it is not uncommon that the importer is an affiliated company to the manufacturer of the cellular phones.

ICT services

Unlike the MPI and the CPI the Service Producer Price Index (SPPI) is a relatively new product at the Price Statistics Unit at Statistic Sweden and the majority of the indices have begun to be published after 2002. The indices of computer consultancy services that we will present below have been produced and published since 2002.

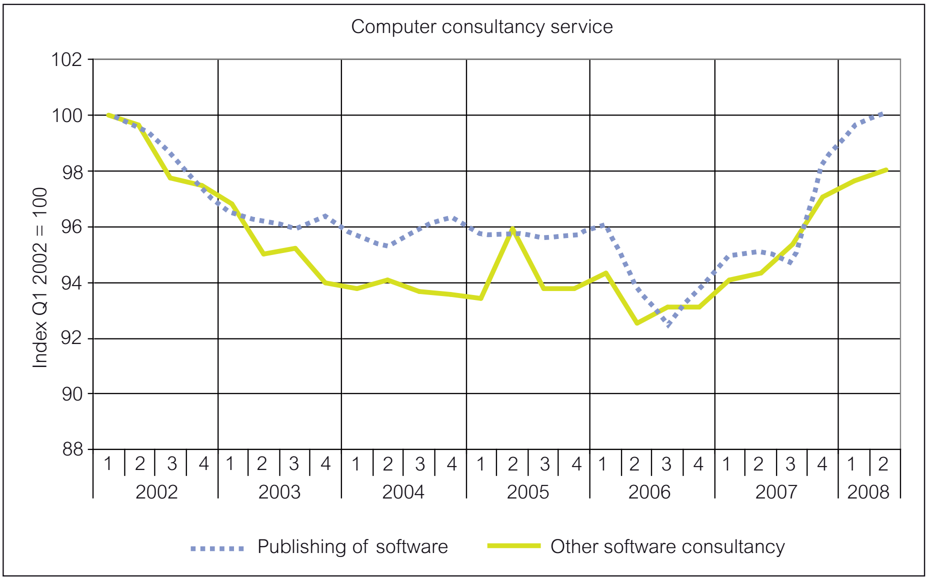
Computer consultancy services

The largest industry in computer services is *Software Consultancy and Supply* and focus will be on this industry. *Software Consultancy and Supply* is divided into two sectors: *Publishing of Software* and *Other Consultancy and Supply.* Indices are calculated for the two sectors. The aim of the indices is to measure the development of prices of computer consultancy services. Like all the SPPI it is from a producer perspective, meaning that the price index should reflect the change of the actual revenue the producer receives.

The method we use to measure the price development is a time based method. Prices collected are the hourly rates for different personnel categories and experience levels where the companies are asked to choose services which they consider are representative and repetitive for their activities. The companies then submit average prices invoiced for these services. Until 2006 the characteristics were pre-defined with five personnel categories and three experience levels but from 2007 the companies may freely choose the categories and experience levels. The change was due to the fact that the respondent's categories differed from the pre-defined ones.

5 *The index for cellular phones in the MPI is calculated by multiplying the index number of each company with its respective weight in MPI. Note that the index for the MPI in the figure is not the official index included in the MPI. In the official figures each company is included separately and not as an aggregated index.*

Figure 4

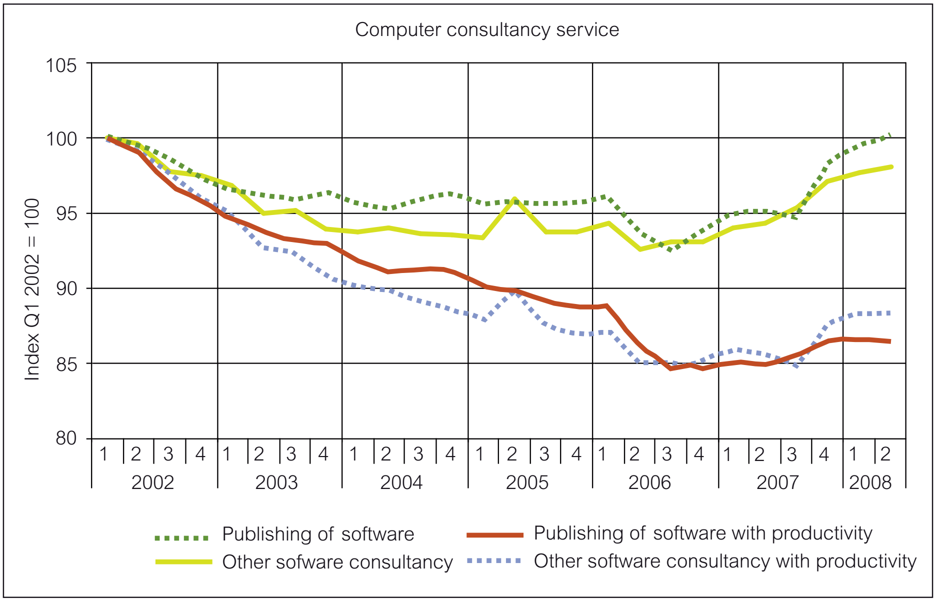


Source: Statistics Sweden

The price development[6] for the two sectors has been quite stable over the period with a U-shaped growth. The time based method being used to measure the development of prices does not encounter any productivity changes. Hence, there is a possibility that the indices above show less price declines than if labour productivity was taken into account. In the figure below we assume that there has been an increase in productivity of 0.5 percent per quarter, i.e. a yearly change of 2 percent.

6 *There is an error in the second quarter of 2005 that led the price level to increase for* Other software and consultancy. *The error was due to incorrect information from one of the respondents.*

Figure 5



Source: Statistics Sweden

An increase in productivity means that the price for the same service has decreased even though the hourly rate has been constant. As we can see in the figure, a productivity growth of 0.5 percent per quarter would imply that the price for the same service in the second quarter of 2008 in *Other Software Consultancy* is merely 86 percent of what it was in the first quarter of 2002. Also, in comparison with the published index, the difference is 12 percentage points. Accounting for productivity also changes the shape of the curves, instead of the U-shaped development the indices have a negative trend almost all throughout the period.

Telecommunication services

The SPPI for telecommunication services is divided into two parts: *telecommunication to business* and *telecommunication to households*. Each part is divided into three submarkets: fixed network telephony, mobile telephony and Internet services. A subset of the telecommunication calculations in the SPPI is used for the CPI.

In the telecommunication to households there is a high turnover of subscriptions which requires a method that can handle the different life lengths of the subscriptions. The method used in the CPI is called *Consumer profiles* and is used for fixed network telephony and mobile telephony.

Consumer profiles represent different consumption behaviour among consumers. The profiles are based on Telepriskollen[7] published by The Swedish Post and Telecom Agency (PTS) and it assumes that the consumer chooses the cheapest subscription contingent on the consumer's calling behaviour. The method was introduced 2005/2006 as a result of the development of the price changes being due to an altered structure of the subscriptions rather than the change of prices for the subscriptions. This trend made it difficult to measure the price changes for the services.

In order to model calling behaviour, 60 different profiles are created. Every profile is defined with a number of calls, how many minutes on high and low tariffs, how many minutes to the mobile net and to foreign nets. The framework for these profiles is based on the Telepriskollen and varies from "low user" to "high user". The profiles are then applied on each provider and a mean of the cheapest subscriptions for each profile is calculated. The price observation for each provider is then calculated as a mean of the profiles.

To measure the price development of Internet services for business and households, subscription fees for different types of access and capacity of broadband connections are collected. Prices for traditional dial-up access are also gathered but the use of dial-up Internet has declined and is probably diminishing. The fastest growing Internet access is wireless broadband connection which from 2008 is measured for both households and business.

Another factor that has to be considered for subscriptions is the length of the contract that the consumer/company signs up for. The methodology used to handle this is called *moving prices* and is applied for Internet (to business) and in fixed and mobile telephony in the CPI. The user is assumed to sign a contract for 12 months and the price of the subscription is the average price for the last 12 months. When the provider introduces new cheaper subscriptions, the consumer is usually offered to make a transfer to the new subscription. In order to incorporate this in the calculations, we assume that in six months after the introduction of the new subscription, all users have transferred to the cheaper alternative.

7 *The Swedish Post and Telecom Agency "…in cooperation with the Swedish Consumer Agency are managing the web-based service Telepriskollen, which enables consumers to compare the total costs of the telecom and Internet providers' various offers" (PTS, 2008).*

Concluding remarks

The purpose of this paper was to describe how some of the core goods and services in the ICT sector are measured. In the introduction we stressed the importance of quality adjustment for high-technology products. For some of the ICT products in the Swedish price indices, explicit quality adjustment methods are used whereas for other products implicit quality adjustment is done. For example, regarding computers, explicit quality adjustment is done in the MPI whereas implicit quality adjustment is done in the CPI. In the implicit method we refer to, the difference in quality between the matched and the unmatched items is included as an assumption in the model. Whether or not this assumption is met should be further studied. Although different methods are used in the two indices they show similar trends over time. Using different methods in the MPI and in the CPI for the same type of goods is not a problem per se since the indices have different purposes.

We also pointed out that the time based method used in some of the indices in the SPPI fail to take into account changes in productivity and that there could be reasons to suspect that the price development is overrated for the period studied. In Figure 5 we showed the price trend when productivity was encountered which led the price index to strongly diverge from the original series.

Over the period studied, improvements of the measurement methods for several products such as cellular phones and telecommunication services have resulted in methods which are more appropriate for ICT products.

Further research is also needed. We suggest that duration studies should be carried out in order to study the life lengths of ICT products. Moreover, options to the time based method needs to be developed so that changes in productivity can be captured in the indices.

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ICT impact assessment by linking data across sources and countries

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Abstract

This Eurostat funded project involving 13 countries, and academic contributors, is designed to meet two key objectives for the European Statistical System

- to develop new indicators on the economic impact of ICT in business without increasing the burden of surveys on respondent firms, and
- to extend consistent analysis of ICT impacts to new countries.

Its results are achieved through data linking across surveys, including (for all 13 countries) the common EU ICT use survey for business, the Structural Business Survey and business register and, for some 'lead' countries, surveys in skills, international sourcing, ICT investment and innovation. Starting from evidence on ICT and productivity from earlier single country studies using firm level data linking, the study group agreed a set of core metrics from common surveys which all countries could analyse, and 'lead' analyses based on data available in groups of countries with additional data. Each is based on the principle that important indicators are those related to productivity and growth impacts of ICT.

In addition to firm level analysis the study has developed an industry based analysis method, using a comprehensive set of metadata, to produce ICT and other indicators on a comparable basis across industries and countries. This allows technology use data to be combined with other – aggregate – economic data in productivity and growth analysis, including EU KLEMS.

The results show additional productivity effects associated with ICT through competitive substitution over and above 'within firm' effects. Evidence from the study suggests that productivity effects associated with ICT use in manufacturing

are relatively consistent across the participant countries, However, effects in services are more diverse, depending on both type of industry, and the level of ICT use in the country. Firm and industry level analyses also suggests that the productivity impacts of ICT are associated with its role in originating innovation, and in enabling firms to replicate successful innovation across markets.

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The full study report was published in November 2008 by the European Commission on its website at http://ec.europa.eu/eurostat/ict, under the heading 'Methodology'.

1) Introduction and Background

ICT indicator development

'Information Society' indicators have a short history in the European Statistical System. Nordic countries, and INSEE, took a significant interest in how information and communication technology (ICT) was being used in industry, and in society, in the mid 1990s, as the use of networks began to impact on more firms and households. Eurostat began to develop approaches based on best practice among its member states. In 1999, the US Bureau of Census made its first (and so far only) survey of computer network use in firms.

The OECD's 1998 ministerial meeting on ICT and e-commerce, initiated both a policy framework and statistical approaches for challenges posed by new technology which:

- made it possible to conduct business electronically ignoring international borders;
- created commercial links bypassing traditional channels of distribution and payment;
- provided opportunities for productivity improvements which did not appear (at least at first) to show up in the statistics.

OECD member states set out to develop common statistical approaches to measuring the information society, at work, in the home and in the wider community. Initial conceptual work on definition of the ICT industries and of ICT products and services, on e-commerce and measurement of ICT use in business and households was led by a small group of countries.

The approach used to develop metrics focused on understanding the transformation of economic and social relationships by ICTs. A linear model was used aimed at understanding:

- 'readiness' of economies and institutions, businesses, households and government, to accept or perform electronic transactions of various kinds,
- 'use' of ICT, e-commerce and electronic business processes, and
- 'impact' or change in behaviour and performance of economic and social actors

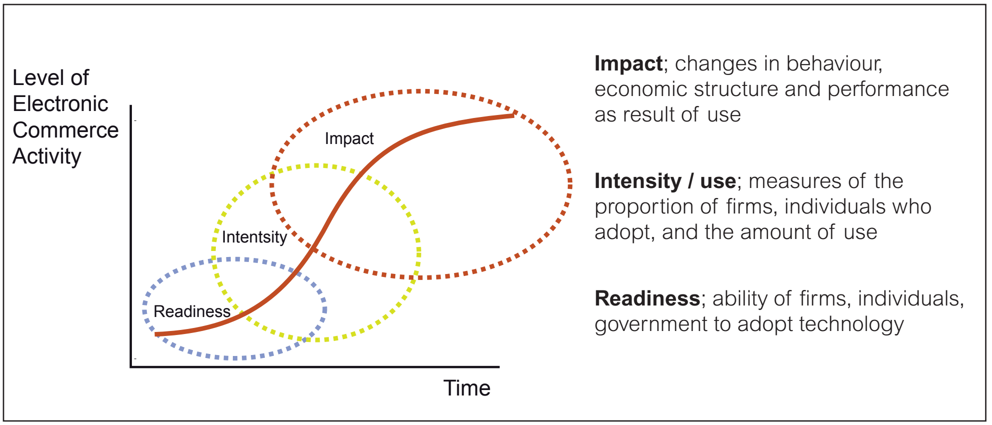

Figure 1 OECD 'adoption' framework

The 'S curve' approach, borrowed from Statistics Canada, was prominent in the first years of statistical development. It accompanied policy focus on building the foundations for internet use, through education, familiarisation, infrastructure in terms of equipment and the creation of networks. There was little empirical evidence on gains from the 'impact' of ICT. The assumption was that economic and social benefits of ICT would become evident, and that Solow's Paradox of 1989 "You can see the computer age everywhere but in the productivity statistics" (Solow R M. 1987) would be resolved. This resolution took over a decade.

OECD developed definitions of e-commerce in use today, and model surveys and metrics which still form the basis of much international comparison work. Most metrics were aimed at the 'use' element of the framework, measuring the behaviour of firms and households, their ownership and use of ICT goods and services, and the proportion or value of sales and purchases executed electronically. There were also measures of 'readiness', gauging attitudes to and opinions of e-commerce or the internet, to try assess barriers to firms' or individuals' use (for non-users), or the self assessed benefits (for users).

Self assessment questions, which covered 'readiness' and 'impact' measures to help policymakers, were the least robust elements of the early framework. An example of the difficulty in interpreting questions relating to 'barriers' came from early results suggesting firms experiencing most barriers were also those which had done most in terms of adoption. Perceptions are unreliable guide to outcomes or behaviour. International comparisons of household surveys suggested perceptions of risk (of fraud etc) were lower in the UK – where incidence was higher – than in other EU economies where incidence was lower.

How indicators have been used for policy

ICT measurement effort was given new impetus by adoption, in 2001, of the Lisbon strategy to promote Europe as a 'dynamic knowledge based economy'. The Council of Ministers committed to policies through which innovation, including ICT use, and designed to promote inclusion and sustainability, would break the trend of poor relative productivity performance of the EU compared to the US. The programme used an 'open method of coordination', with peer review of progress using indicators. This needed a clear evidence framework at all levels.

The EU framework for indicators to support the Lisbon programme covered metrics for the overall economy, for employment, market reform, distributional and environmental effects, and, not least, for innovation. The evidence needed for open comparison of national policy environments was contained in the EU 'Structural Indicators' dataset, developed in 2001/2, and subsequent reviews. This is designed to provide a comprehensive picture of the outcomes of policy (growth, productivity, employment) and of underlying drivers (skills, investment, entrepreneurial activity, technology, training).

Indicators for innovation in the structural indicators include ICT investment and e-commerce use. ICT investment was measured using private sector estimates, because national accounts estimates were not considered reliable, but consistent measures of use of electronic transactions in EU member states were delivered through development of the ICT use survey, led by Eurostat. With a coordinated programme, and knowledge sharing among the EU statistics offices, experience in 'what worked' for ICT use surveys grew rapidly. The survey grew from initial concentration on business use of computers, networks, internet and e-commerce to more complex questions on e-business processes, barriers and benefits of use, employee engagement, security, skills, and other areas.

In addition,to headline metrics Eurostat developed a range of indicators specifically to monitor the 'e-Europe' programme from 2001 to 2005. Most were designed to measure the 'e-readiness' and 'use' stages of ICT development in households, government and business. Attention focused on individual / household measures of IT and internet use, on education and government services, but with the largest section on business metrics. Examples of broader integrated sets of indicators used for policy management include:

- the 'e-government indicators', surveyed for DG INFSO by Cap Gemini Ernst and Young, (Web-based Survey on Electronic Public Services 2002) which tracked availability and sophistication of specific government services in all EU countries, to classify the level of interactive service from 'provides information', through 'provides forms for off line completion' to 'complete transaction'. This is a user centred test of e-business process use.

- UK's e-commerce benchmarking framework, by Booz Allen (Booz A H. 2002), assembled official and unofficial data from leading countries, on readiness / use / impact of ICT for business, citizens and government, and used to identify key areas for focus of government activity, as well as gaps in statistics. Its measures of 'impact' were limited to behaviour change measured through ICT use (e.g. consumer purchases over the internet) and macro-economic productivity estimates of ICT impact via growth accounting.

Development of ICT impact analysis – macro

Early assessments of the economic impact of ICT adoption on an international scale were largely based on macro economic analysis. An OECD review as late as 2003 concluded that 'evidence on the role of ICT investment is primarily available at the macroeconomic level'. This was aided by the decision, in 1993, to treat software investment as an asset under the System of National Accounts (SNA), which allowed analysis of the role of ICT investment (hardware and software) in growth accounting across the majority of developed economies.

Comparisons by OECD in its 2003 report (OECD 2004) show, for the 1990s, how ICT investment contributed to overall growth across 15 member states, and split out the productivity effects for ICT producing industries, and for ICT using manufacturing and for ICT using services. The study highlights the strength of ICT investment in service industries – whereas much of the early impact analysis has been focused on manufacturing for measurement reasons. While it showed ICT investment as a contributor to output growth and productivity, differences in impact between countries were striking.

Strong multi-factor productivity growth in the US associated in this study with ICT use was interpreted as a result of the US' early lead in adoption of ICTs, overcoming adjustment costs and benefiting from competitive markets in which entry, exit and adjustment were easier. For a number of EU economies the contribution of ICT use to productivity growth did not grow as ICT investment grew, and in some it seemed to fall.

A major difficulty in these early assessments of ICT impacts for policymakers was that estimates of ICT investment in macro-economic data were not consistent across countries. Principal reasons for the differences were:

- different estimation methods for software investment (first included as an asset in ESA 1995) with surveys in place in some countries but not others, and major variations in the treatment of 'own account' software written within firms for their own use;

- lack of consistent deflators for hardware and software, and much international debate on the 'hedonic' approach used in the US to quality adjust computer and software prices.

Macro economic estimates through the late 1990s / early 2000s were also complicated by the distortions of the 'dot com boom' which changed market conditions to such an extent that productivity gains were attributed to this rather than to longer run structural or technological change. Productivity gains could be attributed to the (fast growing) ICT producing industries, but universal benefits from investment by ICT users were less clear.

Analysis at industry level is the focus of more recent work in the US, and the EU. Brynjolfsson and colleagues, in 'Scale without Mass' (Brynjolfsson et al, 2006) looked at the relationships between industry ICT intensity, and the characteristics of competition across US industries and concluded that:

- greater ICT use in industries speeds up diffusion of new, successful, business models by 'winning' firms, and is associated with more market share change within these industries;
- the effect of this process is to encourage increasing supply concentration, as successful firms supported by ICT grow, and others lose market share or exit the market.

This US analysis draws no specific empirical conclusions on productivity or on economic performance associated with technology. However the 'KLEMS' initiative starting in 2004 and funded by the EU was designed to take industry level National Accounts data and develop growth accounting models by industry taking account of capital (K), labour (L), energy (E), materials (M) and services (S). Among inputs identified as part of this programme is ICT capital (as part of K).

KLEMS results are still under review, but interim outputs show significant differences across countries, and between the EU and the US, in the growth accounting impact of ICT investment. However, the broad picture demonstrates that:

- differential gains in productivity in more intensive ICT using industries have been an important part of the US productivity advantage over the decade to 2004;
- distribution and business / financial services show the most substantial gains.

The data shows these differences largely in terms of TFP (i.e. unexplained) growth. This suggests that National Accounts data on ICT investment may not be sufficiently well developed to act as a good explanatory variable – essentially the same conclusion as that reached by the compilers of the EU structural indicators. Reasons why IT investment may be inconsistently recorded in official data include:

- the difficulty of extracting survey data from firms on software investment, both on own account work by their own employees which is usually not recorded in accounting systems as capital, and on software which is embedded in IT system purchases;
- differences between countries in the detail with which deflators are applied to different elements of IT, hardware, purchased packaged (i.e. standard) software, purchased bespoke (one off project) software and own account software;
- differences in application of the internationally recommended method for calculating own account software investment across countries.

These issues are explored in work by the UK Office for National Statistics (Chamberlin et al 2006). The implications are that ICT investment may be a useful directional indicator for change in technology investment. However, as the proportion of IT investment becomes more heavily weighted in favour of software rather than hardware, and the proportion of software creation outside the IT industry grows, reliability of official IT investment estimates may become harder to guarantee rather than easier.

An additional factor which affects the pattern of ICT investment, revealed by this project, is the growing importance of IT service outsourcing. Earlier studies have shown the productivity effects associated with offshoring of IT enabled services. Finnish analysis for this project, using survey questions on outsourcing of IT services, shows that productivity incentives for outsourcing IT are strongly positive. This may influence the distribution of IT investment across industries, and make it unrepresentative of the pattern of ICT use, and so of the impact of ICT on business operations. Direct measures of ICT use, from the Eurostat firm level survey, may be a better way of assessing this.

Firm level impact analysis

Early firm level use surveys, piloted by OECD, were implemented in Canada, Scandinavia, Australia and the US in the late 1990s. Starting in 2001 the EU began a sustained programme of implementation and development of ICT use surveys, in which member states were supported in developing practical survey instruments around a common core of questions.

By 2002/3 enough experience had been gained to build confidence in the firm level responses to most questions included in EU ICT use surveys. Researchers started linking the surveys to NSI business output and employment data to test whether productivity differences between firms could be linked to use of information technology or communications.

Use of firm level data to study the relationship between ICT and firm performance spread across a number of countries as soon as consistent surveys became available. Early studies drew on both official and private data sources and used different methodologies. Some examples of some of the different approaches adopted are:

- inclusion of ICT capital stock at firm level as a separately identified capital input in total factor productivity (TFP) analysis (Brynjolfsson & Hitt, 2001; Hempell, 2002);
- inclusion of ICT capital alongside other measures of ICT use, such as internet use or number of employees using ICT (Maliranta & Rouvinen, 2003);
- inclusion of ICT capital stock with measures on innovation and / or organisation change (van Leeuwen & van der Wiel 2003);
- inclusion of measures of computer network use (i.e. behaviour) as an additional determinant of TFP in a productivity regression equation (e.g. Atrostic and Nguyen, 2002).

In 2004 OECD published a portfolio of firm level studies, some comparing ICT impact in different countries, and using similar analytical methods, across 13 countries. In most cases scope for cross-country comparison was limited to two or three NSIs, because of differences in ICT use surveys or in scope to link to other sources. For some countries comparisons could only be drawn for manufacturing, and in some (e.g. Germany) links could, at that time, only be made outside the statistical system. EU member states dominated this first major review which also included Japan, the US, Korea, Australia and Canada.

In 2005 the UK Office for National Statistics published a set of studies (Clayton et al 2005), based on firm level data, which took account of:

- firm level data on IT capital stock, both hardware and software;
- firm level measures of ICT use by employees, of computers and the internet;
- firm level use of e-commerce for both procurement and selling;
- firm level use of communications networks.

These studies showed that while IT investment is associated with increased firm productivity, the effects depend on contingent factors, including whether or not the firm operates as a multinational, whether it has a US home base, its age, and whether it is a manufacturing or service operation. They also showed that:

- greater ICT use by employees has an additional association with higher productivity, over and above the effect of IT investment;
- e-commerce uses for selling and for buying have different productivity effects; for manufacturing e-procurement has a stronger productivity influence;
- organisational differences associated with US ownership influence productivity returns associated with investment in IT hardware for the UK affiliates of US firms;
- greater communications expenditure by firms can also enhance productivity effects associated with IT investment;
- returns to IT investment are also influenced positively by firm level possession of skills (measured by employees with degrees) and by investment in fixed capital.

This work was followed by further analysis of investment in high speed internet by firms and the effects of broadband use on productivity (Farooqui S. and Sadun R. 2006). This suggested – using a a relatively short time series of firm level data – that early broadband adoption by UK firms was biased towards those with high prior productivity, but that subsequent performance showed gains from adoption. The analysis showed that employee use of fast internet connections was a useful productivity indicator, in combination with others

Each of these studies has shown that ICT investment and use by firms has an impact of productivity levels or growth which:

- depends on the sector in which a firm operates, so is business model specific;
- depends on other inputs, related to skills, organisation, or innovation.

It is therefore worth considering, as part of the background to this project, the work which has been done on 'complementary investment' to ICT.

Increasing understanding of 'complementary investment'

Recent productivity analysis (at macro level) suggest an alternative view of traditional accounting approaches to assets in economic aggregates, beyond the standard System of National Accounts, which treats software as investment but treats as intermediates most other 'knowledge' inputs to the production process. For the US and the UK, and a number of other developed economies, new analysis has recast National Accounts to take account of 'intangible investment', including R&D, expenditure on 'non technical' innovation including design, training, organisational change and branding.

Data on these areas are still developing, but the overall picture which emerges from the studies is a growth accounting analysis which is more intuitively sensible over the 1990s and the early part of the 2000s. It shows that:

- intangible investment is a rising part of activity by firms, even if it does not show up in balance sheets, and that software and the associated business process / organisation investment have been the fastest growing elements;
- intangible investment now rivals investment in fixed assets for the US and the UK;
- much of intangible investment is 'capitalised labour' and so shows a different picture of relative returns to capital and labour from that in official economic statistics;
- this treatment captures the major investment by US and UK firms in the late 1990s associated with major business change.

To interpret this macro framework using firm level or industry level analysis requires us to treat ICT as one agent of innovation and growth. Applying this framework at firm or industry level, requires linking to surveys on Innovation and R&D, skills, organisation / e-business links, other 'intangibles' and business performance, productivity and growth.

Our project has set out to do this in specific countries where data are available and linkable to the ICT use survey, and to business output data. This is easier in NSIs which have more developed statistical infrastructure, and greatest capability for data linking analysis. But a majority of NSIs in the project have provided evidence on at least one of these themes.

Overall approach to analysis

In addressing the objectives set by Eurostat in this project, in addition to linking surveys and data sources we set out to link micro (firm level) and macro (industry or whole economy level) analysis. This has advantages, but also poses challenges for statistical analysis.

We have been able to build on earlier studies of surveys, undertaken by the EU and others, on the types of indicators which are most valuable in developing measures of 'impact' for ICTs. The NESIS project, in addressing the relationships between ICT use and business organisation and business processes, had as one of its key recommendations that 'more intensity indicators should be developed on the way from readiness to impact indicators' (Airaksinen A. 2004). The recommendation recognises that the intensity of ICT use within firms is indicative of how far they have changed processes and organisation, or of their capability to change in future. It also provides a useful link to the conceptual macro work on complementary investment.

Eurostat's survey includes questions on the degree to which employees are engaged with ICT, but results for most countries on new questions about how far ICT is embedded in business processes and transactions will not be available until 2009. Our firm and industry level analyses have used intensity measures now available as the best starting point, looking for relationships between usage and productivity or growth.

Firm level analysis of the drivers of productivity and growth is the foundation of our economic understanding of firm behaviour and performance, and of the influence of market conditions and technology change on competitive behaviour. It can be argued, in considering capitalisation of software and R&D in National Accounts, that we should only treat these activities as investment in economy if we can show how they behave as assets for individual firms. This principle has driven much microdata work on innovation.

In addition, insights gained from firm level analysis benefit from much more exhaustive use of data. The range of experience and performance captured in firm level data is much richer, and contains an additional order of magnitude in degrees of freedom, compared to industry level data. Firm level analysis is where we should first pick up signs of impact from use of a technology, by comparing successful and unsuccessful firms. This is usually well before the successful firms have a sufficient impact on industry performance to permit analysis to identify it at the higher level. However, we need to recognise that firm level analysis, of productivity or growth performance of individual units, may not pick up the 'macro' effects of resource reallocation as successful firm grow, and unsuccessful firms shrink or exit.

2) Methods and Data Sources

Overview

The project methodology to develop indicators is illustrated in Figure 2. It starts with a metadata review, to establish what data are held in each National Statistical Institute (NSI) and to identify the variables which should constitute the core dimensions of the project.

The data are described in detail in the report, but the variables include:

- A set of variables on ICT-usage by firms, drawn from the Eurostat harmonised e-Commerce survey (EC);
- A set of variables which describe the economic characteristics and performance of firms, drawn largely from countries' structural business surveys (denoted Production Surveys (PS) in this report);

- Some information on the overall population of firms in each project country, taken from Business Registers (BR).

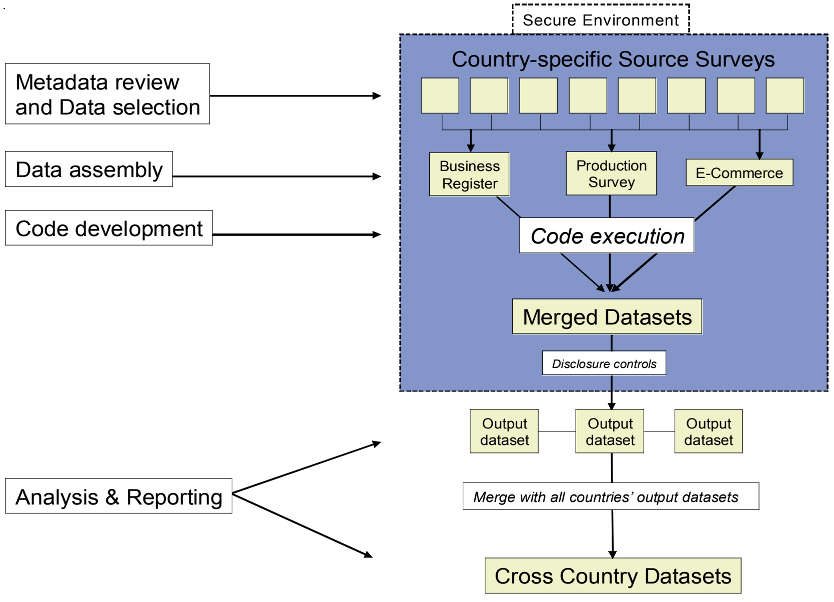

Figure 2: Overview of Project Methodology

Firm-level data drawn from Business Registers (BR), Production Surveys (PS) and E-Commerce surveys (EC) are assembled and processed to create a set of output datasets in each project country. This activity normally takes place in a secure environment, reflecting the confidential nature of the firm-level data. However, the processing is designed to generate *a priori* non-disclosive statistics, being aggregates of firm-level data across one or more dimensions such as industry group, size class, year etc. The process also generates certain direct project outputs such as regression statistics.

Datasets are checked for disclosure before being released from their secure NSI environments and compiled into multi-country datasets. At the present time, access to the multi-country datasets is confined to a subset of project participants. One recommendation of the project is that consideration should be given to providing wider access for research purposes.

Metadata review and data selection

The choice of variables and detailed scope of the analysis has been an iterative process, informed by the knowledge and experience of project members, responses to a metadata survey conducted at an early stage of the project, issues that have arisen in the development of the analytical code and investigation of preliminary results, disclosure issues, the format and scope of the EU-KLEMS database and other factors. Some examples of issues arising from the metadata phase are as follows:

- Unique firm identifiers; the source data in each participating country depends on unique firm identifiers which provide the key to match firms across different surveys and datasets. Identifiers are part of a longitudinal business register which (a) tracks firms over time and (b) is used as a sampling frame for surveys of the business sector, including the structural business surveys and E-commerce surveys.
- ICT investment and capital stocks are highly relevant to analysis of ICT impacts. However, the metadata survey showed only two project members with firm level ICT investment data, and it was decided to exclude it from the core firm level analysis. The two members (UK and Netherlands) undertook a 'lead country' analysis on this.
- Fast internet capacity (*DSL*) and the share of workers with access to such capacity (*DSLPCT*) were added in the light of data showing near saturation of PC-enabled workers (*PCPCT*) and of the results of research using fast-internet usage in the UK.
- Firm-level data on labour skills, such as the share of the firm's employees with post-secondary level education, was added, despite the fact that only a minority of countries have direct survey or administrative data at firm level. Wages / employee were used as a proxy for skills in analysis across the wider project group
- Some ICT business integration questions from the e-Commerce questionnaire have not been included in the core specification, due to incomplete coverage and the costs of data assembly. These data have, however, been included in analysis which has been run by a 'lead' group of 6 project countries.

The e-Commerce survey is harmonised across countries, but one finding of the metadata review is that differences exist in its detailed implementation. Translation of the model questionnaire can lead to differences in precise wording of questions; there are differences in coverage (particularly of optional elements in the harmonised questionnaire), differences in frequency and in the sampling methodology.

Business registers are used to provide a reference framework for re-weighting of sample variables, exploiting the property that the business register covers the whole population of firms, and all business registers carry basic information such as firm employment. However, employment on business registers is not always updated and typically is below employment reported by firms in the structural business survey.

The project design assumes business registers are a source of additional information on firm characteristics, such as age of firm, whether the firm is owned by a multinational organisation, and whether the firm is an exporter. In some countries registers do not contain all these data.

The full set of variables used in the project is shown in Table 1. Appendix 1 at the end of this paper shows how data availability by theme is distributed across countries.

Table 1 – Core Variables and Variables used for 'Lead' Analysis

Variable Name	Description	Domain
E-Commerce Survey Variables		
DSL	Firm has broadband	Boolean (1=Yes, 0=No)
DSLpct	% of workers with access to broadband	Percentage (Range 0–1)
Epurch	Firm orders through Internet (or EDI)	Boolean
Epurchpct	% of orders through Internet (or EDI)	Percentage
Esales	Firm sells through Internet (or EDI)	Boolean
Esalespct	% of sales through Internet (or EDI)	Percentage
Inter	Firm has Internet	Boolean
Interpct	% of workers with access to Internet	Percentage
Intra	Firm has intranet	Boolean
Intrapct	% of workers with access to intranet	Percentage
PC	Firm uses computers	Boolean
PCpct	% of workers using computers	Percentage
Web	Firm has website	Boolean
Production Survey Variables		
Country	**Country code**	**Text string**
Year	Year to which data pertain	Numerical string
Euk	Industry classification	Text string
Sz_Cls	Size class (based on employment)	Numerical class (0 – 7)
Frgn_Own	Multinational dummy	Boolean (1=Yes, 0=No)
SRC	Tabulation type (for sorting data)	Numerical class (1 – 10)
NQ	Nominal sales	Level
NV	Nominal value added	Level
NM	Nominal material inputs	Level
Pay	Payroll	Level
E	Employment	Level
Wage	Derived Pay/E	Level
LnWage	Log of Wage	Level
K	Capital stock	Level

Productivity Variables (Computed by code)		
LPQ	Labour productivity based on real sales	Level
LPV	Labour productivity based on value added	Level
TFP	TFP (Value added with capital and labour)	Level
MFP	MFP (Gross output with capital, labour and materials)	Level
Additional Variables		
Emp_BR	Number of employees given in BR dataset	Level
Export	Export dummy, exporter = 1 non-exporter = 0	Boolean (1=Yes, 0=No)
Age	Age of firm in years	Level
Frgn_own	Foreign owner (Business Register)	Boolean
Hge	High-growth enterprises) (Computed by code)	Boolean
Gzl	Gazelle (Computed by code)	Boolean
Skills		
Hkpct	Number of employees with upper secondary education	Level
Hkitpct	Number of employees with IT upper secondary education	Level
Hknitpct	Number of employees with non-IT upper secondary education	Level
ICT Integration		
intlink_1	Internal link to systems for re-ordering replacement supplies	Boolean (1=Yes, 0=No)
intlink_2	Internal link to invoicing and payment systems	Boolean
intlink_3	Internal link to systems for managing production, logistics or service operations	Boolean
extlink_s	External links to suppliers' business systems	Boolean
extlink_c	External links to customers' business systems	Boolean
intlink_1	Internal link to systems for re-ordering replacement supplies	Boolean
intlink_2	Internal link to invoicing and payment systems	Boolean

There are two methods of adding additional data sources to the core set:

- Include additional variables from the input datasets; an example of this approach is the analysis of data on ICT business process integration (BPI). These data are drawn from the E-Commerce survey but are not included in the core project specification.
- Include data from separate datasets, such as firm level data on ICT investment or capital stocks, data from Community Innovation Survey (CIS), and data on trade and foreign direct investment. As long as such data can be matched through a unique firm identifier we can modify the project specification to incorporate it.

Data assembly

It is unlikely that NSIs hold raw firm-level data in a form and format that can be addressed directly by the analytical code for this project. A central feature of the project is that *identical* code is run in each NSI. Investment in metadata and code methods has been required to achieve this as coverage and scope of available data varies across project countries.

The analysis specification assumes that EC and PS input data is stored in annual datasets of the form "PRE_ECYYYY" and "PRE_PSYYYY" where "PRE_EC" and "PRE_PS" are common prefixes and "YYYY" is the year to which the data pertain (not the year when the survey was conducted, an ambiguity picked up at the metadata stage). The analytical code is specified to read a single BR input dataset, containing register information stacked over all years.

Although the analytical code is robust to missing variables, certain features of the input data are essential for the code to function properly. These include:

- Unique firm identifiers in each of the BR, EC and PS datasets, to enable firms to be matched across different datasets, and the year to which data apply is also mandatory.
- Every firm must be assigned to an industry code. Country specific industry codes are linked to the uniform project industry classification through a user-defined concordance table, which assigns each country specific code to one of the project industry codes.

Issues that have arisen in preparing data include:

- Inconsistent variable naming in different vintages of the source data where survey question numbers have changed over time. The project code only allows a one-to-one mapping of names, and NSIs must ensure that variables are named consistently.
- Missing variables in some survey years, for example, where new questions have been added to the e-Commerce survey. Users must ensure that all variables that are assigned to project variables are found in every annual input dataset read by the code. Where variables are missing, place-holders must be added and populated with missing values.
- It may be necessary to pre-merge data from different source files into the input datasets to be read by the project code. For example, the code is specified to read multinational and foreign ownership flags, and the age of the firm, from the BR input dataset, and data on labour skills (if they exist) from the PS dataset. Where data exists outside the business registers and structural business surveys, it must be merged in.
- Firm level data in Germany are collected and held at regional (Länder) level. These data have been integrated into synthetic national firm-level datasets for this project.
- There are rules for data cleaning. Boolean variables such as *PC* should take the values 0, 1, or missing. Continuous variables such as *PCPCT* should be bounded 0-1 (or missing) in all survey years. Similarly, variables denominated in national currency units in the PS survey, such as value-added, should be in consistent units across survey years.

- Users must ensure that their concordance table links every industry code that appears in their BR, PS and EC datasets to the project industry classification.

Code development

Marrying identical code with varying national data availability is achieved by building dynamic flexibility into the code. Apart from a small number of core variables without which analysis cannot proceed, the code is designed to allow flexibility in to data availability. In running the code, project members in each NSI assign country-specific variable names to each variable, entering a null value if the project variable does not exist in their input datasets. The code then builds dynamic lists of variables that exist.

Similarly the code is dynamically flexible with respect to time periods and will read all annual EC and PS input datasets located in an input directory named by the user in setting up the program run control file. This feature also deals with non-consecutive surveys.

The outputs of the core project code are:

- A set of industry / country indicators built with identical aggregation methods
- A set of results based on running identical regression specifications on the underlying matched firm-level data in each project country.

The code runs in SAS with a duplicate version available in STATA. The SAS code was developed by Eric Bartelsman and tested on UK firm-level data by ONS. The STATA version was developed by ONS, and tested against the SAS outputs using ONS firm-level data.

Running the code

Once input data have been assembled and checked as described, it is straightforward process to execute the analytical code. NSIs must populate the program run file with local parameters to match project variables with local names, and specify which of up to four productivity metrics to use:

- LPQ – log of real gross output per employee. Firm-level data are normally available in nominal terms. Nominal values are deflated using EU-KLEMS industry level deflators. These deflators are not the most disaggregated available for each country, but their methodology is common to all project countries and consistent with the aggregation structure of the project. Since all regressions include time dummies, regression results do not depend on choice of deflator.
- LPV – log of real value-added per employee.

- TFP – a log index of real value added divided by weighted inputs of labour and capital, with weights derived from average factor shares of labour and capital in each industry.
- MFP – a log index of real gross output divided by weighted inputs of labour, intermediate inputs and capital, with weights derived from the average factor shares of labour, intermediate inputs and capital.

NSIs use as many productivity measures as possible given local data availability. If the source data include gross output, value added, intermediate inputs and capital stocks then the code can generate all four productivity metrics. If inputs data are not available, then MFP cannot be computed. If there are no "k" data then neither TFP nor MFP can be computed, and so on.

Disclosure

As shown in Figure 2, the output of the project analysis in each NSI is a set of output files containing statistics derived from the input firm-level data and aggregated over industries, size classes and other categories. The statistics include means and totals, standard deviations, correlations and regression results.

The output datasets also include the number of firms represented by each cell. In many cases the number of firms is measured in hundreds or thousands but in some case the number may be quite small. An example might be for variables drawn from the linked PS-EC surveys for small industries and small size classes.

The process of disclosure control varies across project countries, depending on legal frameworks and local practice. Some countries check outputs and suppress certain results before releasing the outputs to the project co-ordinator (for example by suppressing all outputs where the number of underlying firms is small); other countries carry out no disclosure tests at this stage, but reserve the right to check for disclosure at the project reporting stage. In practice, the number of results suppressed is fairly small.

Once country datasets are approved for release, they are sent to the project co-ordinator and combined with the outputs from other countries and held securely within the project. As some countries have reserved their rights to test for disclosure until the project reporting stage, access to the combined datasets is restricted to nominated and approved researchers from within the project, and is restricted to research conducted under the terms of reference of this project. This part of the process will need to change if the method is more widely used. Data held in the cross-country datasets are purely for research and not official statistics.

Methodology: Rationale and Feasibility

The data-linking analysis used is a combination of co-ordinated firm-level analyses carried out in each separate country, and a programme of analysis of country / industry datasets built from aggregation of comparable linked data in all (or most) countries in the project. It may help to illustrate methodologies by comparing regression specifications:

(i) Regressions on industry/country (DMD) data

$$v_{ijt} = a_0 + a_1 ICT + a_2 k^{IT} + a_3 k^N + a_4 hrs + dummies$$

Where:

v_{ijt}	real value added per employee, in industry i, country j, year t
ICT	indicator of ICT usage for industry i, country j, year t from E-Commerce survey, such as DSLPCT
k^{IT}, k^N, *hrs*	IT capital stocks, non-IT capital stocks and hours worked (all three variables taken from EU-KLEMS dataset
dummies	2 of industry, country and time dummies.

(ii) Regressions on firm-level data

$$tfp_z = b_o + b_1 K + b_2 ICT + b_3 LNW + dummies$$

Where:

tfp_z	total factor productivity for firm z
K	capital stock for firm z
ICT	indicator of ICT usage for firm z
LNW	implied firm-level wage taken from firm employment and wage bill
dummies	industry, size-class, year and other dummies such as multinational status.

The Distributed Micro Data (DMD) approach

In this project, DMD refers to the process of compiling conceptually identical indicators at a relatively disaggregated industry level across multiple countries and multiple time periods. Bartelsman and Barnes (2001) provide two arguments for this approach:

- The DMD approach provides improved trade-off between timeliness and comparability. It is more timely than, say, waiting for Eurostat to harmonise statistics at source, and more comparable than, say, EU-KLEMS data derived from disaggregation of higher level national statistics;

- The DMD approach involves confronting policy questions with data available, and a process of making choices regarding the analyses that can be done. This is a subtle but important point – clearly there are limits on the data that can be collected, and equally there are policy and other research issues that cannot adequately be addressed by the data that are available. Effectively, the DMD approach involves an iterative process between policy questions and data realities.

This iterative process is clearly reflected in this project, first in refinement of the scope of the core analysis and analytical sub-themes, and secondly in the development of the set of data to be collected. For example, fast internet usage was not originally included in the dataset but was added as the project evolved, while other variables that were initially viewed as conceptually important – such as firm profitability, international engagement and ICT investment – have either been discarded or confined to sub-themes.

In addition to these two arguments, the DMD approach is attractive for international policy analysis. In any single country, the impact of a policy event cannot be measured precisely because there is, by definition, only one observation of that policy event. Cross country datasets can help by providing more observations of policy events. In addition, the DMD approach allows summary statistics from the underlying firm-level data to be captured within the country / industry datasets. For example, the project has generated means data for fast internet usage and productivity metrics by industry, country and year which can be expressed as a scatter plot. But behind each observation in the plot, the DMD dataset contains a suite of variables ("indicators") describing the properties of the firm-level data, such as the variance of the firm-level data, and quartile correlations between each variable and other variables of interest such as wage levels, size of firm etc. This integration of firm-level properties with the richness of comparable data by industry, country and time is a key feature of the approach.

Co-ordinated firm-level analysis

The project has conducted co-ordinated firm-level analysis of productivity and core ICT metrics, building on previous work and exploiting the development of comparable linked firm-level datasets. The rationale for this line of work is more pragmatic and opportunistic than the rationale for the DMD approach set out above. There is a natural interest in, say, the comparability of firm level relationships between ICT-usage and productivity across different countries, even if the "meaning" of these relationships is not thoroughly grounded in economic theory, and even if the relationships are not stable across countries.

An example is the employment effects of ICT adoption. Economic theory suggests there should be no such effects, but in practice this is an issue of interest to policy makers. In this regard we see the project as raising questions for further research, rather than providing all the answers.

3) Summary of Results

This section brings together analytical findings from the project. Results derive from the following different types of analytical work:

- at the most basic level, one-off studies of firm level productivity impact where only one country has data to perform specific analysis (eg work from Finland on ICT outsourcing).
- several groups of countries collaborating on micro data analysis for topics where all have similar firm level data which enable a common analytical framework to be used and compared (eg Netherlands and UK on ICT investment, Sweden, France and Italy on offshoring, Sweden, Netherlands and UK on innovation).
- an encouraging range of firm level analysis using common metrics and common analytical code with similar data sources, either carried out by local researchers in countries direct from local datasets, or using the data created for the project and centrally written code to run identical regression analysis, for all countries except Denmark and Slovenia.
- construction of a'metadata warehouse', used to weight and aggregate ICT use, structural business and business register data from surveys in all 13 countries in as comparable a way as possible, producing distributed microdata datasets (DMD); the aggregation process operates to produce estimates of complex indicators (constructed from more than one variable from a survey) as well as indicators which depend on intersections between surveys; this metadata system is also used to generate datasets on a highly comparable basis for firm level regression analysis within countries.
- industry / country level analysis of ICT impacts, using the large (and still under-explored) dataset produced by the distributed microdata (DMD) analysis system, where we have a highly comparable indicators, with the ability to draw reliable comparisons between industries /countries and over time.

Results from firm level analysis

All 13 countries participating in the study have succeeded in producing regression and / or correlation results from firm level data, either individually or using the DMD analysis methodology developed in the project – and in most cases both.

- Project participants have completed analysis to show results relating ICT use at firm level to labour productivity from 11 of the 13 participating countries, on common metrics using an exactly comparable method, and using the common metadata to define and link variables.
- We know we can get results from the remaining countries with minor additional resources; the missing micro-data analysis is due to analytical resource constraints, or to limitations under which access to data was available for this particular project.
- Analysis of the properties of linked datasets in the project, using methodologies developed in earlier studies, shows that sample reweighting, using metadata and methods included in the project, is capable of dealing with most issues of 'representativeness' of data. This breaks down in cases where overlap between datasets is inadequate, and we have not advocated modelling in such cases.
- Linking of datasets in many countries, using sampling designs currently in use, leaves the overlap between ICT surveys and firm performance surveys biased towards larger firms. This affects both firm level and the DMD analyses. For impact conclusions adequately to reflect small firms, sampling strategies would need to change.

Common firm level analysis across all NSIs

The core ICT use metrics used in the project (computer use, e-sales, e-purchases, fast internet enabled or using employees) show reasonably consistent, positive, labour productivity effects at firm level across manufacturing in all countries in the project, beyond the six which have been covered by earlier studies. This suggests that productivity impacts related to use of ICT in manufacturing are now well established and transferable across countries within the EU.

The same core ICT use metrics have much more varied relationships with labour productivity across services at firm level in different countries; for the UK, France, Nordic countries and Netherlands, positive correlations seen in prior studies, and reported in early work from this project are confirmed, in other countries participating in the project, productivity effects are insignificant or even, in one or two cases, negative.

Some correlation is apparent between the countries (Nordic states, Netherlands, UK, France) where ICT use by firms is relatively more intensive and communications infrastructure is strong, or where there is greater market flexibility / dynamism, and the strength of the statistical relationship between ICT use and firm level productivity in services. These differences in impact for services could be explained by a number of factors, including:

- differences in competitive conditions in national services markets, and / or
- productivity gains requiring 'critical mass' in networks and ICT use, and / or
- measurement difficulties in services which are better tackled in some states.

The common analysis shows limited evidence for productivity impact of e-commerce as a variable on its own, and clear positive relationships between productivity and wages (used later in the analysis programme as an imperfect indicator of skills), but little or no separate impact of firm age.

Impact of ICT use metrics compared to IT capital measures

For Netherlands and UK, data are available on firm level IT capital - hardware and software for the UK, hardware only for Netherlands. This makes it possible to test the impact of measures of ICT use over and above those of IT capital services in productivity models. The results show that impacts are differentiated by firm type:

- in manufacturing, intensity of e-procurement shows the strongest link to productivity;
- in distribution services the largest impact on productivity is related to the intensity of use of e-commerce for selling;
- in other, mainly business and financial, service industries the strongest relationship with productivity comes from the proportion of workers with access to high speed internet;
- across all three industry types, IT capital (including software) is positively related to productivity levels in the UK, and with a much larger impact in differentiated services;
- for all three types in Netherlands analysis IT capital (excluding software) is insignificant.

These differences suggest limits to an analytical approach which treats ICT as a 'general purpose technology'. Its impacts in different industries suggest different processes at work, which need to be understood in context, through different effects of information technology (IT) and communications technology (CT). Impact analysis also needs to take account of ICT in combination with other factors such as skills and organisational change.

Fast growing firms

Analysis by INSEE shows that in France, the ***use*** of ICT does not affect the probability that a firm will show high growth characteristics (20% + employment growth over four successive years, not including firms with less than 30 employees). However, French microdata does show that ***intensity*** of ICT use for business purposes (% e-purchases or % e-sales, % employees with high speed internet connection) is a positive influence on the – small - probability that a particular firm will achieve high growth.

Validating these French results using the cross-country (DMD) datasets shows that high growth manufacturing firms are more intensive ICT users in a majority (but not all) of the countries covered, with intensity of electronic transactions appearing to provide the best indicator. Across the DMD dataset, fast growth firms in services in about half the countries are more intensive ICT users for business purposes – but not in the UK or France.

Employment, Skills and ICT Skills

Results from DMD analysis across Austria, Czech Republic, France, Germany, Great Britain, Italy, Netherlands, Norway and Sweden, for 26 sectors of manufacturing and services, show no clear relationship, at industry level, between ICT use metrics (internet and fast internet use by employees) and employment growth. Taken together with the results for fast growth firms above, this suggests that more intensive ICT use may increase the chances of growth at firm level, but this may be at the expense of competitors where industry effects are insignificant.

Three countries within the project, Finland, Sweden and Norway, have'real skills' data available at firm level, derived by linking employer and employee records. In all three there are strong, significant and simultaneous correlations between labour productivity and the proportion of employees with ICT skills, as well as those with other higher education levels. For both types of skill measures the size of productivity impact make a strong case for wider collection of this type of data across other countries.

In Finland and Sweden similarly strong relationships exist between Total Factor Productivity (TFP) and employee skills (both IT and non-IT), and these relationships are significant alongside the 'fast internet enabled employees' measure mentioned above. For the Norwegian analysis fast internet enabled employees appear insignificant in regression analysis together with non-ICT skills, but, paradoxically, ICT skills remain highly significant. General skills appear to have greater impact in TFP analysis, but ICT skills show up as more significant in labour productivity analysis.

In all three countries it is possible to test complementarity of skills and ICT intensity by adding an interaction term (% skilled employees x % fast internet enabled employees) and only in Sweden does this show up as a significant contributor.

From all three countries it is clear that wages have a stronger correlation with productivity than do real measures of skills (this is partly an arithmetic effect as employee compensation is part of value added). The analysis shows that wages have strong limitations as a direct proxy for skills in productivity analysis, without risk of understating other impacts. However, in analyses where skills data are not available, a proxy based on wages may be useful as a check against overstating ICT impacts due to correlation between ICT use and skills.

Organisation / integration of e-business links, and ICT outsourcing

Analysis led by UK, Netherlands and Sweden has used measures of ICT business process integration to test methods of combining existing metrics in the Eurostat model ICT use survey in ways which relate effectively to productivity impact.

Swedish analysis, based on a hierarchical specification of business process sophistication, starting with any form of external link working up to use of e-commerce, internet selling and links with suppliers / customers, and also looking at specific types of links, shows that

- the range of indicators linked to productivity has grown through to 2004, and
- the evidence in support of positive productivity impacts is growing.

However the exact form of correlation, and the channels through which productivity is linked, changes from year to year.

UK results suggest that the productivity effects of linkages depend on the business type, with manufacturing firms showing stronger correlation coefficients between TFP and the incidence of electronic links to suppliers (associated with supply chain management) and service firms showing stronger productivity effects associated with links to customers.

Graphical evidence from DMD analysis across Slovenia, Italy, Netherlands, UK, Czech Republic, Finland, Sweden, Austria, France and Norway shows, for most (but not all) countries, a positive relationship between position in national productivity ranking by quartile and %e-procurement in manufacturing, and for half the countries a similar relationship between productivity ranking and %e-sales in retail and distribution.

Regression analysis using firm-level data from UK, Netherlands, Sweden, France, Czech Republic, and Austria suggests, similarly, that productivity relationships are 'better behaved' for manufacturing, and that elsewhere there are signs of positive relationships, but that a hierarchical model is not the best approach. Regressions also show that external e-business links have more explanatory power than links between processes within firms – suggesting that impacts through market dynamics are more important that efficiency gains through process coordination. The new ICT use survey (2007/8) will provide better,data to explore this.

Data for Finland, which alone among EU countries measures organisational issues, IT mobility and IT services outsourcing, shows significant productivity gains associated with:

- mobile access to ICT by workers (suggesting gains from more flexible work patterns);
- use of outsourced IT services (suggesting gains from specialisation).

IT Investment and ICT use

Evidence from Netherlands and UK, the two countries with firm level IT investment data (hardware only for Netherlands, hardware and purchased software for UK) shows that fast internet connected employees is, for the period, a good predictor of cumulative IT investment.

Evidence from both countries also suggests that the productivity effects of high speed communication used by workers are additional, over and above effects of measured IT investment, and so fast internet use by employees captures unmeasured inputs, knowledge management by employees, and more open, flexible methods of working.

In both countries' data there is evidence that the relationship between ICT investment and ICT use metrics differs across industries and countries, and that additional indicators (eg e-sales, and measures of business IT integration) may be significant; however the directional effects of the available ICT use metrics as indicators of IT investment are similar.

Given the difficulty (and cost) of collecting IT investment data at firm level experienced by most countries which have done it, the continued development of ICT use surveys as proxies for investment, and as indicators of IT impacts, is justified by this analysis.

Offshoring

For France, Sweden and Italy analysis has been conducted to explore the interaction between IT use and offshoring to test indications from earlier studies, and in the wider literature, that productivity advantages associated with globalised supply chains are reinforced by ICT use. Each of the studies uses a methodology which controls at firm level for 'IT maturity' by using a composite indicator from the ICT use survey. In all three the analysis is affected by the fact that offshoring firms are normally at the upper end of enterprise size, by employment.

Results for each country depend on data available. For France, where it is possible to test the relationship between labour productivity and an interaction between proportion of offshored intermediate goods and use of e-procurement, data suggest no cumulative effect. French results suggest that for manufacturing firms there are separate, significant, effects from importing intermediates from high wage economies (large) compared to importing from low wage economies (small).

French data also suggests that the observed productivity effects related to 'IT maturity' do not operate directly through mechanisms associated with offshoring. Swedish data show similar differentiated productivity effects of offshoring to high skill versus low skill countries, but the effects are visible for both manufacturing and service firms. However the offshoring effects are reduced in intensity and in significance by including IT maturity in the analysis.

Gains from offshoring by higher skilled Swedish firms (especially IT skills) are stronger where offshoring is to lower wage economies, suggesting gains from specialisation. The pattern of impacts for other combinations of industry / skill intensity / import source is more complex.

For Italy productivity effects of offshoring, after allowing for IT maturity, are sector dependent. For 'traditional' and 'scale intensive' industries the gains by offshoring to lower labour cost sources are significant; for specialist or science based firms, sourcing from high income countries is associated with higher productivity.

Our conclusion is that it is not yet possible to identify a cumulative effect of ICT use and offshoring of goods on firm productivity. If it were possible to extend the analysis in services the conclusion might differ. Difficulties in linking data are an important limitation to this analysis. The sampling strategies of most NSIs make it unlikely that a firm will be included in trade, ICT use and structural business surveys in the same year.

Innovation (using data from the Community Innovation Survey)

Survey overlaps limit analysis of relationships between ICT, innovation and productivity. However sufficient progress has been made by Sweden, Netherlands and the UK to draw some relatively strong conclusions on the role of ICT in innovation, and the mechanism through which much of the productivity gain associated with ICT may be achieved.

UK analysis linking ICT use surveys to questions in the Community Innovation Survey on sources of innovation shows a strong link between use of high speed internet connections by employees within firms (in the ICT use survey) and the ability to innovate using ideas from outside the firm, and outside the customer /

supplier chain. This suggests a link between fast internet network use and ability of firms to acquire and manage knowledge in the innovation process, to develop higher sales of new goods or services, or more use of new processes.

Evidence from Sweden and Netherlands shows that ICT use – reflected in the proportion of fast internet linked employees and levels of e-commerce – is related to the intensity of firms new products and services sales. This also is likely to reflect network effects on knowledge management, on the effectiveness with which firms are able to convert knowledge into new products and services, and on the speed with which they are able to commercialise them. The impact of e-commerce in Netherlands analysis may be evidence that marketing benefits of e-commerce for innovation (which research has missed up to now) is now visible.

Analysis across all participating countries using DMD shows that in industries which have relatively high levels of ICT use on the core metrics, there also tend to be higher absolute amounts of market share change (or 'churn'). This is consistent with the view that ICT intensive industries in Europe show the same tendency seen in the US by Brynjolfsson et al, for successful firms to be better able, and quicker, to replicate new market share winning innovations across production and distribution networks.

From Sweden and Netherlands there is initial evidence, using datasets restricted by the limits of overlap between production, ICT and innovation surveys, in regressions in which both effects are considered simultaneously, that productivity effects of ICT use are associated more strongly through the 'indirect innovation' effect (percent new products / services) than through ICT use measures directly. The Swedish analysis tests the relative strength of direct and indirect productivity effects and concludes that the ICT => innovation => productivity channel is significantly stronger than the direct ICT => productivity channel for the individual firm. The Swedish evidence is concentrated on larger firms due to sampling effects.

Evidence from Netherlands suggests that ICT use can substitute in productivity equations for the CIS process innovation indicator, indicating that ICT use may be a good proxy for process innovation. This provides statistical evidence for a position argued by researchers, that in service industries particularly ICT introduction is often the embodiment of process change.

As noted above, this analysis has stretched the statistical limits of overlap datasets – showing that the intersection sets of two surveys are often good enough for firm level analysis, but it is much more difficult to achieve significant analysis from matching three or more surveys. This has limited the ability of other NSIs to contribute to the ICT / innovation analysis.

Results of Country / Industry analysis, using aggregated data

The project succeeded in applying the new metadata framework in all participating countries to produce comparable indicators. Results show that the statistical properties of overlap datasets between ICT use surveys and production surveys are sufficiently representative for the moments of the intersections set,to be used in analysis for almost all industries / countries. The project has shown that it is possible to use metadata to deliver useful indicators, including complex indicators drawing on and combining multiple responses within or between surveys.

A major limit on using this approach for wider analytical work, which needs to be tackled by Eurostat, is lack of an agreed approach to publication of aggregated data which, while not disclosive, is at a lower level than NSIs would normally publish. This is a problem for NSIs which are reluctant to see results placed in the public domain which may show unacceptable limits of error for individual estimates, and possibly conflict with official published data.

This problem explains why the report quotes little data from the DMD database built during the project, and that such data are quoted at a high level of aggregation. The industry / country level DMD data have been made available under conditions of confidentiality to analysts working within the project (within the European Statistical System) but under agreements made with NSIs the data is not generally available for research.

These issues of publication for more disaggregated data than NSIs are normally prepared to release are less relevant for cross sectional or growth accounting analysis. These use disaggregated data in ways that do not pose either disclosure or consistency problems to official statistics. Economists in the project team are keen to see this type of data used to broaden the scope of productivity analysis if the publication issues can be resolved.

Analysis on ICT indicators at industry / country level

Analysis across all countries in the study using standard National Accounts based treatment of productivity (as developed by EU KLEMS) shows worthwhile improvement in explanatory power, when carried out with ICT use indicators, constructed using the metadata to ensure comparability. This improvement is partly due to methodological differences in the treatment of ICT (especially software) in National Accounts, ICT metrics delivered by this project are more comparable both in source and in compilation.

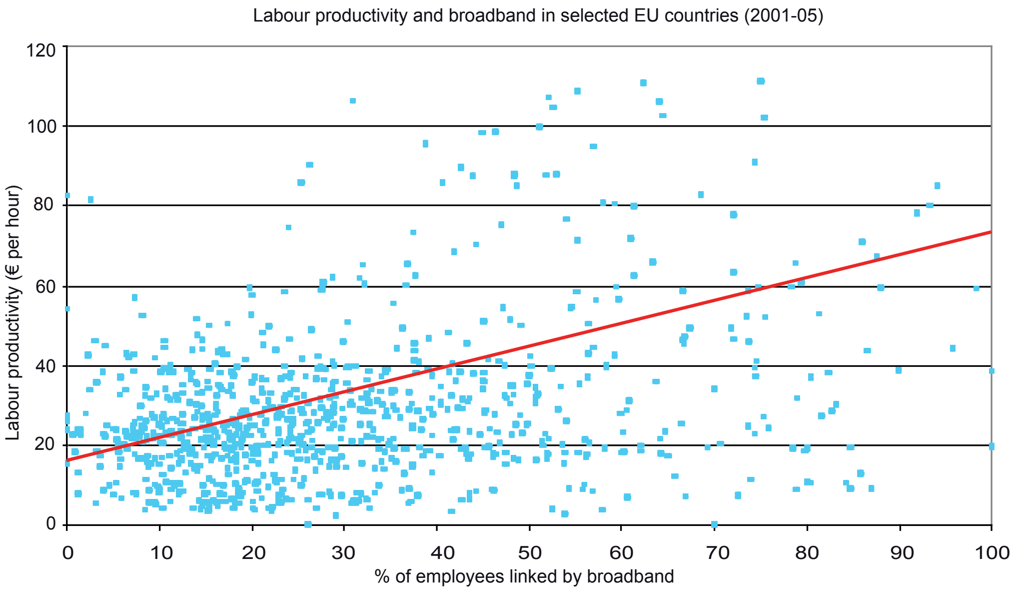

Figure 3

High speed internet use by workers shows up in this cross country analysis as a more powerful indicator related to productivity than e-commerce measures, and as the most effective ICT explanatory input over the period 2000 – 2004/5 over which most of our international data are available. This relationship (Figure 3) is stronger at industry level than at firm level, due to reallocation effects within industries as more successful firms grow.

However, within country analysis of high speed internet suggests (as in the firm level analysis discussed earlier) that high speed internet use by employees is insignificant or negatively related to firm level labour productivity in Germany, Austria and Italy for 2001-2004.

After taking account of factors influencing adoption, both ICT adoption itself and the observed country / industry productivity effects are also positively associated with 'dynamism' of the market – i.e. the ability of ICT users to grow within their markets (and perhaps contribute to market expansion) and to take market share off less successful firms.

This analysis takes account not only of the 'within firm' productivity effects on which firm level analysis focuses, but also of the competitive dynamics and reallocation of resources which takes place within industries due to differential growth, and to entry and exit. The analysis is able to combine indicators built using the metadata approach with measures available at industry level from

National Accounts and labour market statistics including productivity, growth, and – for most countries – ICT capital.

The results of ICT use adoption models using this dataset seem consistent between countries, and the adoption rate is usually strongly associated with worker skills (measured by wages). Productivity regression equations are robust to inclusion of wages as a proxy for skills.

Initial analysis combining this work with measures of labour market flexibility suggests that more intensive ICT using industries make the fastest progress in catching up to the best practice 'productivity frontier' in economies where there is more labour flexibility (measured using OECD's international framework).

4) Conclusions

The Distributed Microdata method

The project has demonstrated, by application in 13 different NSIs, that:

- linked micro-data can be used at the firm level for analysis of productivity effects associated with ICT and with complementary inputs;
- in all these countries it is possible to use a metadata framework to derive, for each national dataset, indicators based on linked data at industry level, and the results of this process can be used either as comparable indicators in their own right, or as inputs to cross-country productivity analysis along with other National Accounts based aggregates.
- The process for using linked surveys to produce industry level indicators can be operated without compromising disclosure practices in each country, and this should allow a useful extension of micro-data analysis across the EU (using ICT and other surveys), subject to appropriate institutional arrangements.

Earlier studies have shown that both IT investment and ICT use are linked to high productivity (in both level and change models). In this project, using indicators directly derived from ICT use surveys we show a positive correlation between productivity and the percentage of workers in an industry with access to (high speed) internet. These results remain, after controlling for ICT adoption. The evidence shows that countries or industries with a high proportion of skilled workers are more intense users of new technology. Further, the amount of variability in firm-level output growth across firms in an industry is seen to boost the intensity of firm use of internet.

A key ingredient missing from the statistical system, for policy analysts interested in productivity mechanisms, is direct evidence on how transactions are conducted in a market place. The underlying 'Keynesian' design of National Accounts has placed little importance on these intermediate transactions. The treatment of large parts of the economy as 'margins' (transport, trade, banking), rather than as creators of value and locations of technological progress is part of this problem. Measures of behaviour which can be integrated into National Accounts, as created here for the role of ICT, can play an important part in improving both the quality and the policy relevance of growth accounting and productivity analysis.

ICT impacts on economic performance

Our results show that the evolution of ICT and its effect on business behaviour and performance is an unfinished story. While productivity effects associated with ICT in manufacturing are becoming standardised across Europe, reflecting success in creating a single EU market and international value chains for goods, there is much less commonality in services. The reasons for these differences still require further investigation. Since services make up such a large part of EU economies this is a natural next step.

We have also seen evidence, in comparing this work to studies of ICT investment, that measurement of ICT capital formation (especially software) poses difficulties for National Accountants. These come both from differences in interpretation and implementation of OECD / UN guidelines for compiling software investment estimates, and from the difficulties in surveying 'intangible assets' such as software at firm level. These difficulties partly explain our results – and why ICT use metrics calculated using distributed microdata do a better job than National Accounts ICT investment metrics in explaining economic impact.

These observed difficulties do not mean that measurement of ICT capital is unnecessary. But the evidence from this study that measures of ICT use can be compiled and used in comparable analysis shows that alternative measures are available, against which ICT investment survey estimates can be benchmarked. Linked firm level comparisons for the UK and Netherlands, two countries for which firm level IT capital stock data exist, show that ICT use metrics (e.g. fast internet enabled employees) can provide a good proxy for IT investment.

A key conclusion is the relationship, in firm level data and in country / industry data, between productivity and fast internet enabled employees. In this sense, the i2010 objective of creating a 'single European information space' can be tracked, in economic terms, by the proportion of fast internet enabled workers. The productivity effect depends not only on this variable's role as a proxy for IT capital, but also because it represents working practices of employees, investment in business processes, knowledge management and organisational capital.

It looks probable – since 'fast internet enabled workers' does not yet show as a productivity driver in service industries in less ICT intensive countries – that it will remain a useful metric for some time to come. The split of four broad industries used in our analysis (ICT goods and services producing industries, non-ICT manufacturing, distribution and non-ICT services) is consistent with the KLEMS classification and also looks to be a useful analytical approach for ICT indicators, given the different results we see between them.

E-commerce (sales and purchases) and e-business links within and between firms also show productivity impacts, with effects of e-sales and e-purchases that are consistent with earlier work, and reflect changes in business behaviour. We have also seen that productivity impacts can be associated with e-business process links, especially between firms, but an effective way to model this must await more extensive data available from the 2007/8 Eurostat survey. It is probable that these will remain useful indicators of change in behaviour and performance.

The most significant set of results from firm level analysis are the relationships from the three countries which have linked innovation and ICT use surveys. These suggest that much of of the productivity impact associated with ICT investment and use is through innovation, including non-technical and business process innovation, through a range of mechanisms:

- by enabling knowledge exchange and management, through networks,;
- by supporting 'roll out' of new goods, services and processes, through ICT enabled business systems which enable rapid scaling up and replication;
- by enabling better marketing of new products / services to new markets via e-commerce;
- by 'being the innovation' in business process improvement and redesign.

This evidence should be considered alongside the growing literature on 'innovation accounting', developing at both firm and national accounts level. This recognises a range of intangible inputs to innovation, including software, technology based R&D, non-technical expenditure on new products and services, skills, organisational and reputation capital. The framework is still under development with major measurement problems especially in the areas of non-technical service innovation (not least financial services) and organisational and business process change. But the role of information and organisation in the 'intangibles' framework suggests that ICT hardware and software are central to its infrastructure.

Looking ahead to a 'next generation' of ICT impact indicators, the changing patterns of innovation should perhaps be an organising framework for thinking about how measures should develop. The interaction between ICT as a knowledge management infrastructure, and the skills (ICT and general) of workers is worth further exploration. So to is the relationship between ICT and organisational / business process change or're-engineering'.

Limited statistical work has been done so far on measuring the increasingly complex use of ICT to manage customer relationships and user input to innovation by firms, in user driven or'open innovation'. However, the arguments above suggest that it should be on the agenda for future investigation of the ICT – innovation links. In the recommendations below we make a number of suggestions on how these links could feature in future surveys.

5) Recommendations from the study

For Analysis

1. The project has shown that distributed micro-data analysis works, that it can be extended to new countries with investment in metadata and analytical capacit, and some central coordination, and that this approach can be used to develop effectively comparable ICT use indicators across countries / industries, using existing sources. We recommend this process, based on pooling detailed survey metadata from each country is extended to as many other countries as are willing to use the model. This could be coordinated by Eurostat, or, with Eurostat support, by the expert group created in this project.

2. The project has shown that new indicators, or new formulations of indicators to reflect interest in specific industries or firm types, can be generated by country / industry across the EU quite quickly, using existing surveys if the necessary metadata structure is put in place in advance. This provides a more flexible approach to indicator development and adaptation than the current Information Society Statistics regulation, and should be considered as a useful addition to the IIS regulation.

3. In order to conduct distributed micro-data analysis it is necessary to link ICT use surveys with production surveys. Therefore there is a good case for building up the metadata structure covering the ICT use survey (which is relatively easy as all countries undertake a similar survey), and as an absolute minimum, metadata for those parts of the production surveys and administrative data systems which help to weight linked surveys for industry level analysis. Developing the metadata structure to include all those areas of the production surveys and business registers used in this study (see Table 4.1, Chapter 4), would be the best option, and is recommended.

4. Linking through the metadata approach should be done between ICT and innovation surveys, to test the models developed in this project across the few countries where linking is already practical. These suggest that ICT is central to

parts of the innovation cycle. More extensive analysis of the relationship between ICT use in firms and steps in the innovation process, broadly defined to include non-technical innovation, would improve understanding of key elements in the working of ICT impacts. We recommend that this should form part of a further, limited, study. Much groundwork for this has already been done by OECD's Working Party on Industry Analysis.

5. The analysis has shown that for those countries where data on firm level IT investment are available, as well as ICT 'intensity of use' indicators, there is a strong relationship between them. Some of these indicators are good proxies for IT investment as measured directly in surveys, and ICT use measures also proxy relatively well for the effects of IT/ CT and other forms of complementary investments. In part this is because firm surveys find it hard to capture some elements of IT spending (especially own account), and therefore use surveys may give more reliable indicators of ICT intensity. We recommend that these conclusions be taken into account in assessing the value, frequency and priority of firm level IT investment surveys.

6. The analysis of productivity effects of ICT, at both firm and industry level, has tended to confirm the view that impacts for ICT can best be measured through ICT in use (i.e. measures of what, and how much, firms do with ICT) rather than ownership measures of ICT assets. Such measures are preferred, in terms of explanatory power, to less effective statistics on ICT investment, in part because of the difficulty of measuring different elements of ICT capital. We recommend that in developing analytical frameworks for impact assessment this principle – that what matters is what and how much, firms do with IT, rather than whether they have it, is given priority.

7. Frameworks for assessing impacts for ICT should recognise the different roles that ICT plays in the different stages of the innovation process Especially in service firms, hardware, software and communications systems determine the adoption of new work practices and knowledge management systems, and may embody changes in business processes. We recommend that analytical frameworks for further indicator development should explore these areas in greater depth than we have been able to. The evidence from this project would justify further analysis, supported by new survey data if possible, on the role of ICT in, and between, firms as:

- infrastructure for knowledge gathering from outside;
- the basis for knowledge management and diffusion within the firm;
- the central element in commercialising new goods, services and processes and replicating them within and beyond the firm;

- the key driver of business process change, combining with complementary intangible investment to enable productivity improvements directly.

For Surveys

1. Current surveys on which we have based this project are designed for existing 'single survey' compilation of ICT penetration and use aggregates. Few NSIs have yet designed ICT use surveys specifically to make the most of microdata analysis based on data linking, although all are conducted using business registers which permit linking. Also, within the European Statistical System ICT use surveys and Innovation surveys have grown up separately, which may make them more difficult to link, because of differences in some countries in business reporting unit definition. Given the conclusions reached in analysis for countries where the two can be linked we recommend that further thought be given to examine the way ICT use and innovation surveys are done in order to improve the links between data sets. The options available might include

- an 'innovation module' in the next available ICT use survey to investigate how firms have used ICTs to change their products, services and processes, rather than a focus on 'static' questions about what business process links they use ICT for, as in the current survey;
- redesigning the ICT use and innovation surveys so they work better as complementary surveys, with linkable questions on how ICT is used to develop new products, services and processes, both in technology based and in non-technological innovation, including new organisational and business process developments;
- converge the two surveys, with less emphasis on ICT questions asking about specific technology and more emphasis on asking how ICT use changes firm behaviour, employee behaviour and the relationships with suppliers / customers (although merging surveys could lose valuable information);
- include in both surveys questions that facilitate analysis toward the inter-relationship between intensity of ICT and degree, and model, of innovation. This would preserve the advantages of each survey, but at the possible cost of additional compliance burden on respondent firms.

Careful thought will need to be given in survey development to the fact that ICT and innovation surveys are currently answered, in many firms, by different respondents, and require different knowledge. This is a strong argument for keeping the surveys separate, and starting future investigation with an 'innovation module' in the ICT survey. However, some of the innovation issues, on organisation and business processes, may well be accessible to ICT managers as easily as R&D managers who tend to answer current innovation surveys.

2. The recommendation above would improve understanding of the process of innovation in services, which is often organisational rather than technological, and enable us to get over the current 'two survey limit' which in most countries makes it very difficult to assemble a sample for analysis of ICT, innovation and business performance in any but the largest firms. This constraint needs to be overcome for effective analysis on larger numbers of firms, or for focusing on specific business types. The new questions on data exchange and on electronic supply chain management in the model 2008/9 survey could provide a base from which such questions could be developed.

3. An innovation module would also build understanding of the relationships between ICT, innovation and business performance in smaller firms, where the current sampling and survey structure gives very little data to analyse. The analysis in this project has done enough to show that the innovation and productivity effects of ICT differ between broad business types – and are reasonably common in manufacturing firms across all 13 countries. We recommend that developing better data to support analysis for services (often comprising smaller firms) should be a priority as the ICT survey develops.

4. We recommend that consideration is given to asking about how, and how intensively ICTs are used to acquire and manage knowledge, to develop and commercialise new products and processes. Existing data in a few countries are adequate to suggest links between ICT and the innovation process. However, there are questions which the Eurostat common survey does not currently ask about issues such as co-innovation through information exchange, ICT to support flexible working arrangements, and ICT to aid outsourcing, which could be interesting as impact indicators. In those countries which do ask such questions they turn out to be significant as determinants of business performance.

5. We recommend that Eurostat should consider paying equal attention in survey and sample design to generating aggregates in ICT use surveys (which currently dominates survey specifications), and to the design of surveys to support the exploitation of microdata for impact analysis (today not considered at all), which focuses on differences between respondents in a survey, and which often depends on intersection of linked surveys. This change would affect questionnaire design, sampling and the use of panels. In development of the Community Innovation Survey in a number of countries more attention is now being given to building panel datasets, to support better analysis of technology adoption and its impact on firms over time. Similar attention in ICT use surveys would be useful, especially for smaller firms where panel elements in existing surveys are very small.

For Indicators

1. The project has produced a 'complex' indicator, using two elements of the ICT use survey which is strongly linked to productivity at firm or industry level for this decade. The 'fast internet enabled employees' metric is a proxy, in economic terms, for the 'common European information space' over the last five years – and for some time ahead. It has greatest impact in more knowledge intensive industries, and is linked, in analysis, to the innovation process.

2. It has also produced clear evidence of links between ICT intensity in EU industries and countries, and competitive dynamics. In more ICT intensive industries (measured by use) the tendency of firms to gain or lose market share is larger. There is also evidence that the combination of more dynamic markets (entry / exit / innovation) and ICT use is complementary for productivity improvement. Complex indicators which bring these two together will be worth considering.

3. Complex indicators representing the complementary use of ICT, and engagement in innovation (technological, organisational, or other), would also be worth considering on the basis of evidence from the study. This would require the CIS survey to be added to the metadata framework. The relationship between skills and ICT could be one candidate for a complex indicator, either through CIS linking (using CIS higher education questions) or using the ICT skills data from the 2007 model survey to test ICT use / skills complementary effects on productivity

4. In our analysis we have shown that greater intensity of ICT use (on various measures) is related to other metrics of 'business change' – in the broadest sense defined by the innovation survey, and that at least some of the productivity gain attributed to ICT investment and use can be traced back to ICT through innovation. If this conclusion is right, and policymakers need indicators to help explain changes taking place in firms, and across industries, then it makes sense to look for measures which relate to the main sources of competitive growth. In this study we have shown evidence for several such indicators, and suggested a framework which relates ICT indicators to sources of growth. A summary is shown in Appendix 2.

5. The NESIS project in 2004 recommended greater use of intensity indicators, some of which have been developed in Eurostat surveys. This study has shown that 'use intensity' indicators using existing surveys are more effective indicators of ICT impact than simple 'possession' or 'expenditure' metrics. Developing the conclusions of both these studies, we can suggest future benchmark indicators, some of which could be developed from Eurostat surveys in the pipeline, while others will require new survey questions, or recasting of the relationships between ICT use and other surveys to permit more extensive linking. Suggestions include attempting to gather information on firm spending on complementary investment to ICT, which has been successfully tried by industry experts in the UK.

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Appendix 1: Data available for the project by theme and country

	AUT	CZE	DNK	FIN	FRA	GBR	GER	IRE	ITA	NLD	NOR	SLO	SWE	TOT
Firm characteristics														
Employment on BR	●	●	●	●	●	●	●	●	●	●	●	●	●	13
Sample Weight on PS	●	●				●	●		●	●			●	7
Sample Reweighting	●	●			●	●	●		●	●	●		●	9
Multinational flag on PS		●			●	●				●			●	5
Ownership flag on PS		●		●	●	●		●		●		●	●	8
High growth firms	●	●		●	●	●	●	●	●	●	●	●		11
Gazelles (age on PS)				●	●	●			●			●		5
Gross output on PS	●	●	●	●	●	●	●		●	●	●	●	●	12
Value added on PS	●	●	●	●	●	●	●	●	●	●	●	●	●	13
Nominal materials on PS	●			●	●	●	●	●	●	●		●	●	10
Payroll (wage) on PS	●	●		●	●	●	●	●	●	●	●	●	●	12
Capital Stock on PS	●	●		●	●	●	●		●	●	●	●	●	11
Productivity Variables														
Productivity LPQ available	●	●	●	●	●	●	●		●	●	●		●	11
Productivity LPV available	●	●	●	●	●	●	●	●	●	●	●		●	12
Productivity MFP available	●		●	●	●	●	●		●	●			●	9
Productivity TFP available	●	●	●	●	●	●	●		●	●	●		●	11
ICT Key Variables														
PC	●	●	●	●	●	●	●	●	●	●	●	●	●	13
Web	●	●	●	●	●	●	●	●	●	●	●	●	●	13
Epurch	●	●	●	●	●	●	●	●	●	●	●	●	●	13
Esales	●	●	●	●	●	●	●	●	●	●	●	●	●	13
Inter	●	●	●	●	●	●	●	●	●	●	●	●	●	13
DSL	●	●	●	●	●	●	●	●	●	●	●	●	●	13
PCpct	●	●	●	●	●	●	●	●	●	●	●	●	●	13
Epurchpct	●	●	●	●	●	●	●	●	●	●	●	●	●	13
Esalespct	●	●	●	●	●	●	●	●	●	●	●	●	●	13
Interpct	●	●	●	●	●	●	●	●	●	●	●	●	●	13
Intrapct	●	●	●	●	●	●	●	●	●	●	●	●	●	13
DSLpct	●	●	●	●	●	●	●	●	●	●	●	●	●	13
ICT Other Variables														
Mobility				●										1
IT Outsourcing				●										1
IT Business Integration Links	●	●			●	●				●			●	6
Other firm-level data														
ICT investment						●				●				2
Trade flows					●				●				●	3
Human capital / Skills				●							●		●	3
Innovation						●				●			●	3

Appendix 2:
Indicators in the project using existing data, and suggestions for the future

A: Framework for 'sources of growth' which can be described using existing surveys

Firm level	
Source of growth	**Possible role of ICT**
Acquisition of knowledge from outside the firm	Internet links to professional experts, 'customer driven' idea generation
Managing knowledge to formulate commercial ideas	Internal networks between people
Turning ideas to delivered products/services	Replicating product / service through ICT based 'enterprise architecture'
Marketing to target customers	Use of CRM systems, or web marketing
Industry / economy level	
Source of growth	**Possible role of ICT**
Faster spillovers of knowledge between firms	Industry levels of internet exchanges
More efficient markets, speeding up reallocation	e-commerce penetration
Supply chain management / optimisation	e-procurement

B: Indicators which can contribute as impact measures, related to sources of growth

Measure / indicator	Element of growth contribution
From existing data	
Fast internet enabled employees, by firm and industry	ICT investment, knowledge acquisition and management
% e-sales, by firm and by industry	Marketing efficiencies / targeting
% e-procurement, by firm and by industry	Supply chain management, market efficiencies
ICT investment / employee use	Enterprise architecture, to replicate processes
Dynamism (share change) in high ICT using industries	Speed of reallocation of resources
From data in the 2007/8 and 2008/9 surveys	
ICT skills and ICT use in firms	Ability to absorb and manage knowledge
Summation of e-business links	Internal / external business systems, and ability to replicate new products / processes
Intensity / extent of information sharing (from 2008/9 survey)	Internal / external coordination, and ability to replicate new products / processes
From survey extension / better linking	
Skills and ICT overall capability – needing a linkable skills question	Absorptive capacity of firm for new ideas
Investments complementary to ICT, requiring some form of expenditure question (e.g. how much spent on process redesign compared to ICT)	Training, business process change etc; how much firms invest in 'business change'

Shaping Policies for the Internet Economy

Andrew W. Wyckoff, Organisation for Economic Co-operation and Development, Paris, France[1]

Abstract

ICT policy development has been underway at the OECD and by extension its Member countries for over a quarter of a century. Characterised as sectoral or technology policy, the subject area was usually the domain of Ministries of Industry or remnants of regulatory agencies from an era when the regulation of monopolies was the main focus of policy. In the mid-1990s this view began to change as technologically-led developments lead to the widespread diffusion of ICT through the economy and society. ICT began to be seen as an enabling infrastructure ("the information highway") and a driver of macroeconomic growth ("the new economy"). With the advent of the 21st Century – ICT has burrowed deep into every segment of the economy and is now quickly becoming part of the social fabric.

This transformation was recognised at the recent OECD Ministerial meeting on the "Future of the Internet Economy" held in Seoul Korea in June 2008 and is reflected in the declaration that Ministers adopted at that meeting. The declaration is supported by a framework of policies, *Shaping Policies for the Future of the Internet Economy*, which set the declaration into a policy context. This paper borrows heavily from that work, and is intended as a checklist for policy makers to consider when formulating policy in this area, as well as a point of reflection for analysts and statisticians who seek to provide an evidence base for policies in this area.

1 *The views expressed here are those of the author and do not necessarily reflect the opinions of the OECD, its governing Council or its Member countries.*

Introduction

1. The Internet is transforming our economies and societies. It provides an open, decentralised platform for communication, collaboration, innovation, productivity improvement and economic growth. Along with information and communication technologies (ICTs) it promotes closer integration of the global economy and interactions that increase general well-being. As the services it supports become pervasive, ubiquitous and more essential in everyday life, the *economy* is increasingly the *Internet economy*. The capacity of economies and societies to seize opportunities and meet challenges in a wide range of areas – the environment, education, health, demographic change and, more generally, the delivery of commercial and government services – already involves the use of ICTs, seamlessly interconnected by the IP-based networks of the Internet.

2. Promoting the Internet economy is a way to improve our ability to boost economic performance and social well-being, and to strengthen societies' capacity to improve the quality of life for citizens worldwide. OECD countries share a vision of the Internet economy, as articulated in the Seoul Ministerial Declaration[2], in which its expansion is a way to bolster the free flow of information, freedom of expression and protection of individual liberties, as critical components of a democratic society and cultural diversity. Better use of the tools it provides can help address global challenges, such as climate change. To give concrete form to this vision requires awareness in the policy community of the increasing economic and social importance of the Internet.

3. Clearly, the Internet economy is already an important and growing part of our economies and societies, but to reach its full potential in meeting economic and social objectives, a policy environment in which the Internet's role as catalyst can be maximised is essential. Key areas that require policy attention include: a smooth transition to next-generation networks to maximise the benefits of *convergence*; fuelling *creativity* and innovation to underpin economic growth and employment; and increasing *confidence* in the Internet infrastructure, applications and services.

4. The paper seeks to provide guideposts for shaping policies and practices for the future of the Internet economy in this rapidly changing and inherently global area. It does so by versioning an OECD report, *Shaping Policies for the Future of the Internet Economy*[3], developed for the OECD Ministerial Meeting on the Future

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2 *Available at* http://www.oecd.org/dataoecd/49/28/40839436.pdf

3 *Available at* http://www.oecd.org/dataoecd.org/dataoecd/1/29/40821707.pdf. *The framework of policies includes an annex of specific policy guidance in nine areas, three of which are OECD Council recommendation or "soft law" that represent a political commitment of OECD Member countries. This annex is available at* http://www.oecd.org/dataoecd/1/28/40821729.pdf

of the Internet Economy held in Seoul, Korea in June 2008[4]. That report brought together the work of 5 OECD Committees (described in Table 1) that examined policy issues in 20 areas critical to the Internet economy as well as identifying linkages and gaps in policy domains where future work may be useful.

Benefiting from convergence

5. An initial policy focus is the further diffusion of broadband, the infrastructure of the Internet economy. Using a variety of technologies, certain OECD countries have reached nearly 100% broadband coverage and many countries have may great strides in extending broadband to rural and remote areas. Throughout the OECD area, average broadband prices have fallen while average speeds have increased. In a growing number of countries "last-mile" copper-based connections are being upgraded to facilitate greater high-speed connectivity. Access by households, businesses, governments and schools has significantly improved as has the range and use of applications, content and services.

6. These new technologies, tools and innovative services have made it easier to take advantage of the opportunities made available by the Internet infrastructure, but the economic and social implications are only beginning to be understood. Broadband networks allow the expansion, aggregation and globalisation of markets as well as the customisation of goods and services and the largest productivity gains will come increasingly from the use, rather than the production, of networked ICTs. The implications for all users are multifaceted and far-reaching. For example, by empowering consumers through greater access to information, facilitating price comparisons, increasing competition and creating downward pressure on prices, the Internet has begun to transform the relationship between suppliers and customers, creating opportunities for new user-driven business models.

Next-generation networks

7. The most pronounced impact is on what used to be separate networks for voice, video and data which thanks to the superior technical properties of the Internet are migrating rapidly towards platforms based on the Internet Protocol. This "convergence" is forcing changes in both business and policy models, necessitating a review of regulatory environments to ensure that existing regulations will be effective in the new environment; and to develop new solutions when they are not.

8. Common economic and social regulatory objectives for communication services presently include: universal service requirements; competitive access to network bottlenecks; consumer protection; access to emergency call services, media

4 *See* http://www.oecd.org.futureinternet *for material related to the Ministerial.*

plurality and cultural diversity; data security and consumer privacy; competitive markets that offer essential services at cost-based prices; and continued innovation and investment in new technologies, services and applications.

9. Key policy issues associated with convergence and next-generation networks include:

- Reassessing the applicability of existing regulation to encourage investment by the private sector and competitive choice in the market place. Current economic regulation needs to be reviewed to ensure that it does not act as a barrier to the ongoing process of convergence and therefore prevent the development of more efficient means of delivery of existing and new services. At the same time policy attention may be required if advanced technologies or commercial activities result in new dominant positions in any market in the value chain.
- Facilitating the development of high-speed broadband networks with enhanced upstream and downstream capabilities, in particular advanced wireless and fibre networks; maintaining and enhancing conditions of effective competition; reducing barriers to entry by improving the development of, and access to, passive infrastructure and ensuring fair and non-discriminatory access.
- Encouraging the development of technology-neutral regulation where appropriate to ensure fair competition and the development of a level playing field. This would include interoperability, interconnection, spectrum management, emergency services, number portability, security and integrity of networks, and consumer protection and information.
- Reviewing existing rules in light of the convergence of telecommunication and broadcasting, and developing cross-media policies for a multi-platform environment.
- Taking into account the increasing ability to provide cross-border services that are not constrained by either geography or a given network when promoting access to local content.

IP addresses

10. All devices connected to the Internet need IP addresses to communicate. As the convergence of communication platforms moves towards including the Internet Protocol, IP addresses become crucial to the increased scalability of the Internet and thus to the continued growth of the Internet economy. Deploying the newer version of the Internet Protocol, IP version 6 (Ipv6), is necessary to enable billions of people and devices to connect to the Internet. The current pool of unallocated IP version 4 (Ipv4) address blocks is declining and will be depleted within the next few years. Shortages are already acute in some regions underscoring the need to create a policy environment conducive to the timely deployment of IPv6 while maintaining security and stability, as well as service continuity. Policy efforts should focus on working with the private sector and other stakeholders to increase education and awareness and reduce bottlenecks; on demonstrating government commitment to adoption of IPv6; and on pursuing international co-operation and monitoring IPv6 deployment.

Empowered consumers

11. Over the last decade, increased competition and the development of a range of new products have transformed the communication services sector. They have brought significant benefits to consumers and other users, including falling prices, higher-quality services, a wider choice of service providers and access to new services. These trends are likely to continue, and even intensify, as next generation communication infrastructures and services are put in place.

12. These changes have, however, created challenges. As communication services have become more complex, it is increasingly difficult for consumers to evaluate and compare alternatives. Pricing structures may not be clear and contracts may limit consumers' ability to switch providers or terminate a contract easily. Yet, it is increasingly recognised that communication services markets can be strengthened by consumers who can, through well-informed choices, help stimulate price competition, innovation and improvements in quality. By making well-informed choices among suppliers, consumers and users not only benefit from competition, they help drive and sustain it.

13. The focus is on how to promote market transparency and more effective consumer protection, while maintaining an environment that encourages investment in developing new communication services. Some important elements that deserve consideration include:

- Encouraging the development of services that provide consumers with a range of quality products at competitive prices.
- Informing consumers about potential security and privacy risks in using communication services and available measures to limit these risks.
- Enhancing consumers' awareness of the availability and benefits of services and suppliers and of consumers' rights.
- Improving the transparency of contracts and ensuring that they are not unfair to consumers.
- Minimising the costs associated with switching services.
- Facilitating timely, inexpensive, easy-to-use, effective and fair settlement of consumer complaints.
- Ensuring that services are widely accessible to all, and, in particular, to disadvantaged and vulnerable consumers.

Sensor-based environments and ubiquitous networks

14. Radio frequency identification (RFID) enables wireless collection of data on electronic tags attached to or embedded in objects, for identification and other purposes. It has been used for many years in transport, access control, event ticketing and management, more recently in government identity cards and passports, and extensively in manufacturing supply chains and in logistics for goods distribution. It can be viewed as a first step in the direction of"ubiquitous networked societies".

15. In the longer term, small wireless sensor devices embedded in objects, equipment and facilities will increasingly help individuals in their daily tasks and enhance business processes, supply chain management and quality assurance. They will enable distance monitoring of ambient conditions *(e.g.* temperature, pressure) and be used in a myriad of new applications, in areas such as health care and environmental monitoring. They are likely to be integrated with the Internet through wireless networks that will enable interconnectivity anywhere and at any time. While the future uses and capacities of technologies that bridge the physical and virtual worlds are still largely a matter for speculation, they are expected both to bring economic benefits and raise societal challenges. Today's concerns related to the invisibility of data collection by RFID devices and to the ability to trace and profile individuals may be exacerbated if tags and readers become pervasive and are combined with sensors and networks.

16. Policy development in this area need to consider:

- Encouraging the development and adoption of open global standards and their harmonisation within and across sectors. As far as possible, this should be addressed through market mechanisms and should involve all stakeholders.
- Facilitating applications when considering spectrum licensing and allocation and encourage the development of internationally compatible applications.
- Adopting a comprehensive approach to developing a security management strategy, including security risk assessment. Where appropriate, participants should also take a comprehensive approach to designing and operating a privacy management system, including an impact assessment and implementation of technical security and privacy protection measures.
- Collecting or processing information relating to identified or identifiable individuals using these systems needs to be undertaken with the knowledge and, where appropriate, the consent of the individuals concerned.
- Individuals provided with functional tags need to be informed about the existence of the tags, associated privacy risks, and mitigation measures – whether or not personal data is collected.

Promoting creativity and innovation

17. The Internet and ICTs enable and support creativity and innovation, encourage entrepreneurial activity, and stimulate the restructuring of industries and institutions. They account for a significant share of research and development (R&D), patent applications, firm start-ups and venture capital. As a major depository of information, the Internet also facilitates co-ordination and co-operation among researchers and entrepreneurs, linking the creativity of individuals and allowing organisations to collaborate, pool distributed computing power and exploit new ways of disseminating information (*e.g.* via the participative web, social networking tools and virtual worlds, and new open access repositories for scientific and technical data).

18. Cross-disciplinary, mutually reinforcing policies and initiatives are necessary to boost performance and enhance the Internet's role as an enabler of innovation. Four areas require particular policy attention: *i)* strengthening the use of the Internet by government, business and research communities; *ii)* ensuring open and collaborative mechanisms, including for developing open standards and interoperability for the Internet of the future; *iii)* supporting development and use of digital content and public-sector information; and *iv)* encouraging the use of the increasingly participative web across a widening range of economic and social activities.

ICT-enabled research and innovation

19. The Internet and ICTs are profoundly changing how research and creative activity are undertaken (*e.g.* distributed research, grid and cloud computing, virtual simulation, virtual worlds), with potentially major impacts on innovation and growth. They are fostering new types of market-based entrepreneurship and encouraging people outside of traditional institutions and hierarchies to collaborate to produce content, services and goods. The Internet enables the rapid diffusion of codified knowledge and ideas, thereby linking science more closely to business, and facilitates the development of informal creative networks. Central to this is open access to the vast amounts of information and data available over the Internet.

20. Maintaining an open and interactive environment may require adapting public investments in research and technology and public funding and incentives for R&D and innovation (*e.g.* tax incentives) to ensure that they cover new research domains and new ways of organising research and innovation. These include:

- Developing software, networks, broadband content and related services as the core of new strategies for stimulating creativity;
- Strengthening Internet-based collaborative research and experimental networks;

- Promoting access to digital research information;
- Developing new models of scientific and technical digital publications to further improve access.

Digital content and services

21. Digital content products are driving the market for mobile services and applications and stimulating demand for new infrastructure, content and skills. Platform convergence (video, voice and data), rapid diffusion of high-speed broadband, increasing upstream as well as downstream bandwidth and the evolution towards information-rich, knowledge-intensive economies will further underpin growth. Rapid changes in the value chains for content development, production, delivery and use, as well as the creation of new commercial and non-commercial models to exploit these opportunities, challenge both existing business models and policy paradigms.

22. Because the marginal costs of exchanging and reproducing information and digital content are very low, the challenge is to facilitate access to and use of digital content and develop new business models while preventing unauthorised use. Intellectual property rights (IPRs) grant exclusive rights to an original invention or work for a limited time and are important for commercialising inventions and artistic works. These rights are balanced by public interest obligations regarding access to and dissemination of knowledge and creative works (disclosure obligations for inventions and fair use, fair dealing and exceptions and limitations for copyright). The music and video industries are still grappling with these issues as they seek to develop new, more effective and popular ways of commercialising their products on line.

23. Policy can help foster the creation, access to and use of digital content by:

- Providing incentives for the creation, dissemination and preservation of digital content (*e.g.* open innovation strategies, university-business collaboration, incentives for long-term research and intellectual property rights), and encouraging investment in this area.
- Facilitating global access to content regardless of language and origin.
- Encouraging technology-neutral approaches, interoperability and development of open standards when addressing technological issues.
- Improving information and content quality and accuracy through policies to facilitate the use of tools that help creators identify and disseminate their works and users to identify and access specific information and works.
- Recognising the rights and interests of creators and users, in areas such as the protection of intellectual property rights while encouraging innovative e-business models.

- Addressing shortages in skills, training, education and development of human resources for the creation, distribution and use of digital content.

24. Public organisations are a major source of information, an increasing amount of which is digitised or produced in digital form and can be re-used in innovative ways for significant economic and social benefit. While commercial and non-commercial access to, and, re-use of, public sector information and content is generally becoming more open, obstacles sometimes impede efficient and effective use, such as restrictive or unclear rules governing access and conditions of re-use; unclear and inconsistent pricing of information if re-use is chargeable; complex and lengthy licensing procedures; inefficient distribution to final users; and barriers to development of international markets. The role of public sector organisations as collectors, producers and disseminators of public-sector information is not always clear, particularly in competitive market areas.

25. Specific policy options in this area include:

- Maximising the availability of public sector information for use and re-use based upon the presumption of openness as the default rule.
- Encouraging broad non-discriminatory competitive access and conditions for re-use of public sector information by eliminating exclusive arrangements, and removing unnecessary restrictions on the ways in which it can be accessed, used, re-used, combined or shared.
- Improving access to information and content in electronic form and over the Internet.
- Finding new ways to digitise existing public sector information and content, to develop "born-digital" public sector information products and data, and to implement cultural digitisation projects where market mechanisms do not foster effective digitisation.
- When public sector information is not provided free of charge, pricing it transparently and consistently within and, as far as possible, across public sector organisations so as to facilitate access and re-use and ensure competition.
- When public sector information is not provided free of charge, costs charged should not exceed marginal costs of maintenance and distribution. Any higher pricing should be based on clearly expressed policy grounds.
- Exercising copyright in ways that facilitate re-use, and where copyright holders are in agreement, developing simple mechanisms to encourage wider access and use, and encouraging institutions and government agencies that fund works from outside sources to find ways to make these works widely accessible to the public.

Participative web

26. The participative nature of the Internet encourages social and economic interaction, innovation and value creation. Broadband access, the development of user-friendly web platforms, collaboration tools and other social networking software are enabling hundreds of millions of private and professional users to participate in the construction, development and use of Web 2.0, the participative web. It offers opportunities for entrepreneurial, organisational, professional and personal activities and new kinds of open research, innovation and value creation. It also facilitates new forms of citizen participation in public life, the free flow of information and freedom of expression. The policy challenge is to encourage innovation, growth and change and develop appropriate governance that does not stifle creativity or affect the openness of the Internet.

27. With the rapid growth of user-friendly social networking sites, large amounts of personal information are being exchanged in ways that may not have been anticipated in privacy frameworks or not covered owing to different national approaches to privacy and data protection. Well targeted "behavioural" advertising can provide services and other benefits to users, but the accumulation of personal data on which it depends also creates privacy and security risks if the information is not used responsibly. Emerging policy issues include: the rights and obligations of content creators, the drivers and barriers to competition, and the applicability of existing business and technology policies to these new environments. The wide range of policy issues associated with the participative web, ranging from technical development to responsible use, will need to be addressed.

Building confidence

28. The Internet has become the information infrastructure of the global economy. The increasing volume of e-commerce and online financial transactions, the roll-out of e-government, the development of collaborative and social networks, and emerging trends towards the creation of an "Internet of things" mean that building and maintaining trust in the Internet and related ICT networks must be a key policy area. The confidence of the end user is essential to building that trust and to the continued growth of the Internet economy. When it is shaken, even mildly, it is difficult to regain. To prevent loss of confidence, policies and measures are needed, from increasing the security of information systems and networks to creating trustworthy digital identities, to protecting consumers, personal information, minors and other vulnerable groups, and more broadly to fostering transparency and fairness.

29. For example, the Internet is an integral part of children's lives in many countries. It is a source of information and entertainment, plays an important role in education, and is increasingly part of their social environment. However, these benefits create risks in areas such as online identity theft, bullying, stalking, access to inappropriate material and loss of privacy. To build confidence, children, and their parents, need the knowledge and tools that make it possible to remain safe on the Internet. More broadly, governments, the private sector, civil society and the Internet technical community need to collaborate to build an understanding of the impact of the Internet on minors in order to better support and protect them when they use it.

30. Another example is the changing privacy landscape. New technologies are bringing dramatic changes to the collection, storage and use of personal information (*e.g.* storage is inexpensive, so data tend to last forever; the sheer volume of personal data now maintained by organisations is overwhelming; data can be transferred with just a click of the mouse; processing tools are powerful, ubiquitous and cheap; much personal information is searchable, linkable and traceable by search engines, location-based services, RFID and sensors). Trends in globalisation, fuelled by these technological advances, have multiplied data flows. This leads to changes in the behaviour of organisations and individuals, bringing new opportunities for individual expression and greater efficiencies for organisations, but also an increase in privacy-related risks. These include data breaches facilitated by the volume of personal data being transferred and used or risks related to secondary usages of personal data. Recent efforts by a cross-section of the privacy community to help refine approaches to privacy are an important step towards better protecting personal data in a challenging and changing environment. Multi-stakeholder co-operation will be needed to assess current OECD privacy instruments in light of changing technologies, markets and user behaviour, and the growing importance of digital identities.

31. As the Internet increasingly supports the development of the global economy, its continuous availability, reliability and security are vital to governments, businesses and individuals. Increasingly, governments need to work with all stakeholders to anticipate threats within and to the online environment. One way to do so is to strengthen efforts to develop a culture of security so that users better understand the nature of the risks and are aware of the tools that can protect them. Governments also need to co-ordinate their policies to respond to potential threats by supporting law enforcement co-operation, establishing public-private partnerships and more generally designing appropriate policy frameworks to provide protection at the level of the network infrastructure, in online marketplaces and for Internet consumers.

Critical information infrastructures (CII)

32. Critical infrastructures are increasingly interdependent and rely on the effective functioning of ICTs. The monitoring and control of power grids and water plants, for example, often depend on the functioning of underlying IP-based networks. Further, most industrial control systems that monitor and control critical processes are increasingly connected, directly or indirectly (through corporate networks), to the Internet and therefore face new threats. Finally, malicious activity on line is increasing and adversely affects all Internet users and activities. Unfortunately, critical information systems have not proven immune to this phenomenon. This is a national policy priority which requires co-ordination with private-sector owners and operators of critical information infrastructures and co-operation across borders.

33. Specific policy recommendations include:

- Identifying government agencies and organisations with responsibility and authority to implement clear policies to protect CII and ensuring the transparent delegation of responsibility to facilitate closer co-operation within the government and with the private sector.
- Consulting with private-sector owners and operators of CII to co-operate on the implementation of these policies and enabling regular exchange of information with the private sector by establishing information-sharing arrangements that acknowledge the sensitivity of certain information.
- Co-operating among governments and with the private sector at the strategy, policy and operational levels to ensure the protection of CII against events and circumstances that individual countries would be unable to address alone.
- Conducting a risk assessment based on an analysis of vulnerabilities and threats to the CII, in order to protect economies and societies against the risks of highest national concern.
- Developing an incident response capability, such as computer emergency response teams/computer security incident response teams (CERTs/CSIRTs), in charge of monitoring, warning, alerting and carrying out recovery measures for CII.

Malware

34. Malicious software, or"malware", is used for information and identity theft or denial of service attacks. If unchecked, it could undermine confidence in online markets. Spread across the Internet in various forms, malware exploits common network vulnerabilities, degrading the integrity and security of the system as well as the data within it. Malware has the potential to adversely affect any and all Internet users, from enterprises to governments to end users. To improve what is still a fragmented, local response to a global threat, more structured collective action is needed by those with responsibility for combating malware. However, these actors need a common point of departure from which to build co-operation. They need to come together, share information, understand each other's challenges, and look at the problem collectively and comprehensively. Such a partnership should aim to develop a policy framework at domestic and international levels to address economic, legal, technical, information-sharing and incident-response issues related to malware and enhance collaboration among all the public and private sector communities affected by, and involved in, fighting malware.

Digital identities

35. Trustworthy user identities are essential to the sustainable growth of the Internet economy. The management of digital identities encompasses processes and tools that operators of online systems can use to establish a person's *identity and control* access to and use of resources within that system. The possible benefits of effective identity management to e-commerce, e-government and social interactions are enormous.

36. Research by the OECD and others shows that to be effective, identity management systems will have to be deployed in a manner that maintains user confidence on line by minimising information security risks and individuals' risks to their privacy and individual liberties. It will require an approach that blends good design and usability, appropriate security, user education and awareness, and a legal and policy framework to protect digital identities and associated personal data and to allocate risk. As the Internet economy develops, the protection and management of digital identities will be one of the most important public policy issues shaping the future of our e-society. Clearly, secure digital identities as well as effective systems to manage them and to protect individuals' privacy will help reduce identity theft.

Online identity theft

37. Identity (ID) theft occurs when a party acquires transfers, possesses or uses personal information of another party (*i.e.* a natural or legal person) in an unauthorised manner, with the intent to commit, or in connection with, fraud or other crimes. It is an illicit activity with a long history which has expanded as the Internet and e-commerce have developed. Today, victims' personal information is being obtained on line through the use of constantly evolving methods and techniques, including malware (harmful software), phishing (fraudulent solicitation of personal information), and spam ("junk" mail).

38. There are three basic elements to combating online ID theft: prevention (*i.e.* what can be done to lower the risk of identities being stolen); deterrence (*i.e.* what can be done on the enforcement front to discourage theft); and recovery and redress (*i.e.* what can be done to facilitate recovery of stolen IDs and obtain compensation or other redress for the harm caused).

39. Combating online ID theft includes pursuing initiatives that focus on:

- Alerting and educating consumers and other stakeholders to new and existing techniques being used to steal identities on line and to measures which consumers and other stakeholders can take to protect their identities while on line.
- Collecting and disseminating information on developments and trends relating to online ID theft and its economic impact on stakeholders.
- Encouraging business and governments to examine ways to improve the security of consumers' personal data and raising their awareness of the benefits of using electronic authentication tools.
- Developing legal definitions of the concept of ID theft, with a view towards facilitating co-ordination of domestic and international efforts to prevent, deter and provide redress against such theft.
- Requiring companies to take more steps to prevent ID theft, such as disclosing data security breaches affecting their customers when those breaches could result in ID theft, or improving customer authentication when providing services or transactions.
- Exploring ways to strengthen efforts to combat ID theft, for example, by introducing more dissuasive sanctions, increasing co-ordination of cross-border enforcement and providing more effective mechanisms for victims to recover identities and obtain redress.

Consumer protection and mobile commerce

40. Mobile commerce refers to interactions and commercial transactions conducted through wireless communication services and networks by short message services (SMS), multimedia messaging service (MMS), or the Internet, using mobile devices. Quite a broad range of activities is already being carried out on mobile devices, including the purchase of goods and services, payment for public transport and the management of banking transactions and accounts. Technological advances suggest that consumers and users will continue to be presented with new ways of doing business.

41. The rapid growth of mobile commerce has, however, created challenges for consumers and users because the small screen size and the limited storage and memory capacity of mobile devices limit the information consumers receive about transactions. The use of mobile phones by minors, in particular, raises concerns about potential commercial exploitation and misuse, with potentially significant financial and privacy implications. In addition, a number of questions have to be resolved as regards liability in cases of fraudulent use of mobile devices.

42. Practical suggestions for addressing challenges that consumers increasingly face in the mobile commerce marketplace include:

- Developing practices to ensure that consumers using mobile devices are provided with adequate information for making informed decisions about the products and services they purchase and the firms with which they do business, and that they know the costs, terms and conditions of mobile transactions, including ways to verify and confirm them.
- Developing policies and tools to ensure that minors are protected from adult and other inappropriate content on the mobile platform, and to prevent minors from engaging in excessive or inappropriate transactions through technological means and increased education and awareness.
- Helping consumers avoid the risks of unauthorised use of mobile phones by educating them about ways to protect themselves from loss and misuse, by encouraging stakeholders to develop policies and tools to deter unauthorised use (including the development of security precautions and built-in security features), and by exploring means of enhancing consumers' liability protection in mobile commerce transactions.
- Developing policies and tools to limit the sharing of consumers' personal data and enable them to decide with whom to share such data, including data on their physical location, and to encourage mobile operators to implement data security policies and measures to prevent data breaches.
- Developing dispute resolution and redress policies aimed at establishing fair, effective and transparent mechanisms to respond to consumer complaints in relation to both domestic and cross-border mobile commerce transactions. Inexpensive and easy-to-use means of redress should be available when consumers suffer financial loss or their data are compromised as a result of a mobile commerce transaction. There should be clear information on the entity or entities responsible for handling claims involving mobile operators and other mobile service providers.
- In addition, in view of the dynamic nature of mobile commerce, governments and other stakeholders should continue to track developments and work together to address emerging issues in a timely fashion.

Developing a truly global Internet economy

43. A global Internet economy would give people of all countries access to communication services that can enable and enhance their economic and social development. While there have been remarkable developments in this respect in recent years, much remains to be accomplished: four-fifths of the world's population lacks ready access to Internet services. Two issues are particularly prominent. One is the need to build appreciation, among all stakeholders, of the opportunities that the recent successful growth of communication networks can also create for developing countries. Second, as this network of networks becomes increasingly pervasive worldwide, more effective cross-border co-operation mechanisms for preventing malicious and criminal activity should be developed. By addressing these issues governments can empower users worldwide through broader access to a trusted online environment.

Developing Internet access

44. The policy and regulatory changes needed to enable people at all levels of society in developing countries to begin to share in the Internet/ICT revolution include reducing the barriers and access costs, and providing people with the skills needed to make the Internet truly accessible and universal.

45. To extend the benefits of Internet access around the world, policies need to:

- Promote the liberalisation of communication markets to create the necessary conditions for investment, competition and growth.
- Separate operational and policy responsibilities and create an independent regulator with the power to enforce appropriate regulatory safeguards where competition is insufficient.
- Promote partnerships with the private sector and civil society to enhance market access and capacity building.
- Support developing countries' efforts to develop the skills and capacities to take advantage of ICTs as tools for poverty reduction.
- In countries where Internet Exchange Points (IXPs) do not yet exist, build an understanding of their benefits and the barriers to their creation; these are largely not financial but the conditions that would enable IXPs to operate efficiently and become industry-driven.
- Facilitate the development and implementation of internationalised domain names in a way that supports the continuing security and stability of the Internet.

Co-operation on regulatory enforcement to protect users on line

46. Maintaining trust on line requires laws and enforcement authorities that are able to work together across borders to ensure a basic framework of user protection. OECD governments have developed policy frameworks to assist in cross-border co-operation on law enforcement in the areas of consumer protection, spam and privacy. Their efforts have shown that the types of challenges facing regulatory enforcement authorities overlap substantially and that informal networks linking these authorities are essential for successful cross-border co-operation. They have also found that the problems facing users on line are increasingly serious.

47. As the global reach of the Internet increases, it is necessary to ensure that regulatory enforcement co-operation expands as well. Objectives for the future include the need to increase the horizontal sharing of good practice among authorities in different areas, to improve practical support for and linkages among informal enforcement networks, and to continue efforts to better understand the number and nature of cross-border problems faced by users, for example by developing internationally comparable indicators.

Looking forward: the future of the Internet economy

48. The move towards an Internet economy began little more than a decade ago when the Internet became available commercially thanks to the liberalisation of telecommunication markets and the development of user-friendly applications and services (e-mail, the browser, the web). What many considered a novelty ten years ago has since become a fundamental part of the economy and society. As the Internet now serves more than one billion users, the world's economy is now an Internet economy. Ten years ago, few would have predicted that broadband access, Internet telephony or social networks would become a mass phenomenon. The speed of Internet-induced change and the potential further effects on our economies and societies during the next decade make it essential to look forward and outline a future policy agenda.

49. Convergence, the development of next-generation networks and high-speed wireless networks, and the diffusion of RFID and other automatic identification technologies are expected to change the functionalities of the Internet. At the same time, this network of networks is becoming more global as it is transformed into a platform for economic and social interaction involving both people and objects. Many of the issues discussed in this paper, such as improving broadband access, expanding digital content, improving access to public sector information, and countering identity theft are well-defined, with policies already in place in many countries. However, rapid changes taking place in many areas may lead to new issues which may need monitoring or changes in existing policy frameworks. These areas include:

- The evolution of communication platforms towards next-generation networks, many of which are based on new technologies such as fibre optics, and high-speed mobile networks that fundamentally change market dynamics, usage patterns and consumer behaviour.
- The shift in access from PC-based to mobile, hand-held devices which will become more pronounced as non-OECD economies increasingly go on line.

- The advent of sensor-based networks that create demand for infrastructure capacity, change the nature of monitoring and controlling production and distribution, and raise issues of privacy and security.
- The explosive growth in digital content, the shifting boundaries between physical and digital products and experience, and the development of virtual worlds which raise a host of new policy issues and will test established policy frameworks.
- Further developing ICT-based systems and Internet-connected sensor networks and other applications to improve energy efficiency, reduce emissions, and improve resource use and early response to pollutants.
- Improving energy efficiency, material use, recycling and end-of-life disposal in the production and use of ICTs, for example through life-cycle audits of ICT equipment and effective policies and targets in areas such as energy labelling and disposal regulations.

50. Some of these developments are still at a very early stage but they point already to the need for long-term policy-related analysis to ensure that competition is maintained and enhanced in communication markets, to determine how to protect digital identities, to ensure that consumers are adequately protected and empowered in e-commerce and evolving markets for communication services, and to encourage new digital content services and creativity.

Strengthening the evidence base for policy making

51. In this rapidly changing environment, reliable evidence is needed to support policy debate and formulation and to determine the effectiveness of practices.

Statistics and indicators

52. Statistical systems must be able to follow adequately changes in access to and use of the Internet and related ICT networks by citizens, businesses and institutions. Indicators and metrics that take account of the diversity of IP-based networks and of economic and social flows over these networks are necessary to provide reliable measures of evolving uses and of the impact of the Internet on economic performance and social well-being. They can also create incentives for deploying the networks that provide the connectivity necessary for the development of the Internet economy. In particular, indicators and analysis are needed to:

- improve our ability to identify the drivers of Internet access and applications and measure its use by citizens, businesses and institutions; price is assumed to be a key determinant affecting access but our volume measures for many communication services have failed to capture large quality changes associated with the increased functionality enabled by broadband or mobile access;

- enable the evaluation of the impact of the Internet on economic performance, notably on productivity and innovation which will require improved methods of capturing complementary investments (e.g. organisational change, skills development, adaptive innovation) that are needed to realise productivity gains.
- broaden the scope of data collection to the social realm where ICT is affecting the formation and sense of communities, and affecting the nature of education, health and government services;
- enhance our understanding of differences and barriers to its use, especially as regards issues of confidence such as the weight assigned to the privacy of personal information or to the risk associated with potential security breaches;
- enable a better understanding and quantifying of various aspects of the Internet, such as its size, areas and patterns of growth, or potential vulnerabilities, through the measurement of Internet traffic flows.

Analytical work

53. Analytical work is needed to better understand a number of pressing economic and social issues that are affected by the Internet and the Internet economy that it underpins.

- Foremost among these is a need to better understand the role and contribution of the Internet and related ICTs as a driver of productivity and economic growth. Central to this is harnessing the Internet as an open platform that dramatically alters the innovation process by lowering barriers, broadening collaboration and engaging more people in creation.
- Analysing the economic, social and cultural impacts of emerging Internet technologies, applications and services, including virtual worlds, sensor-based networks and social networking platforms.
- Examining the roles of various actors, including intermediaries and gateways such as Internet service providers, payment providers, search engines and auction sites in meeting policy goals for the Internet Economy; these intermediaries also have the potential to be a valuable source of data on the Internet economy.
- Researching how the Internet and related ICTs are used in addressing climate change and improving energy efficiency as a basis for developing appropriate policies. ICTs and the Internet hold out an opportunity to make the application of market mechanisms practical (e.g. real time pricing of electricity); by optimizing the movement of people and things; and by monitoring the environment in real time.

- Conducting analysis and formulating policy guidance for the development and use of converged communication networks which views these networks not as narrow conduits for voice and content but rather as a fundamental economic infrastructure akin to roads, ports or the banking system;
- Assessing the impact of changing technologies, markets and user behaviour on concepts of privacy, security, identity and consumer empowerment. As the individual becomes more of a focal point of the Internet economy, it is not a surprise that the currency of the Internet economy is personal information. The growth of business models built around the mining of this data and the explosion of social networking sites, require us to better understand and analyse changes both from an economic and a social perspective – what are the risks, what are the benefits? and how do we adapt policy to this new environment?

Conclusion

54. This paper has outlined a number of policy issues that require attention from statisticians, researchers and policy makers as economic growth and social welfare is underpinned by the Internet and the related ICTs that connect to it. The dominant messages include:

Improving economic performance and social welfare

- Policies affecting the Internet can no longer be seen as narrow sectoral policies having to do with telecommunications, but as mainstream economic policies reflecting the fact that the Internet has become a fundamental economic infrastructure. So called"technical issues"(e.g. Internet addresses or network management) should be seen as enabling factors for economic performance and social welfare more broadly.
- The Internet offers a huge potential to address pressing global issues that we are facing, such as sustainable economic growth, climate change, aging society and energy efficiency.
- We need a reliable and uniform system of indicators to measure changes in access to, and use of, the Internet and related ICT networks by citizens, businesses and institutions.

Benefiting from convergence

- Convergence of information and communication platforms, new generation networks and high-speed Internet access are benefitting society, but their rapid development is challenging regulatory bodies, as existing approaches are often inadequate to respond to rapid changes in markets. Changes in policies and regulations should focus on two principles – promoting competition and protecting consumers.

- Users have now become active drivers in the changes taking place in technologies and related services and can help create competition if sufficient flexibility and the ability to choose among service providers exists.

Promoting creativity

- The Internet is lowering barriers, broadening collaboration and the exchange of ideas – the essence of innovation – fundamentally changing the nature of innovation which has implications across a number of policy domains.
- Relations between amateurs, professionals and creativity are shifting, unlocking new pathways to the production of knowledge. Among other implications there is a need to work out how governance of intellectual property will be collectively managed.

Building confidence

- The Internet can make life easier for everyone, from people in remote villages to global enterprises. However, the features that make the Internet so attractive – openness, anonymity and global reach – create potential vulnerabilities such as data breaches, identity theft, cyber fraud and the growing problem of malicious software.

Expanding the global Internet Economy

- Efforts to expand access need to continue so that more of the world's population is part of the Internet economy. Mobile devices with Internet access, could contribute importantly in this regard as their use in developing countries is advancing rapidly. Policies that are pro-competitive and technologically neutral are important for creating an "enabling environment" conducive to investment and diffusion.

55. In the near future, access to the Internet is poised to jump from more than a billion to several billion as users outside of the OECD connect, mainly through mobile devices; it is likely to connect to a trillion sensors that will generate terabytes of data and it will evolve from being mainly a commercial platform to a social network connect that is intimately connected to our everyday lives. This requires that policies must be developed with humility, cognisant of the rapid, unpredictable nature of change that requires that policies be fashioned in a flexible, upgradeable manner.

Table 1. Analytical Background papers for the Future of the Internet Economy Ministerial

Building awareness of the importance of the Internet economy
Monitoring the Recommendation of the Council on Broadband Development
Broadband and the Economy
E-Government for Better Government

Benefiting from Convergence
Convergence and Next Generation Networks
Internet Address Space: Economic Considerations in the Transition from IPv4 to IPv6
Enhancing Competition in telecommunications: protecting and empowering consumers
Radio Frequency Identification (RFID): A Focus on Information Security and Privacy
RFID Applications, Impacts and Country Initiatives

Promoting Creativity
Digital Broadband Content: Digital Content Strategies and Policies
Digital Broadband Content: Public Sector Information and Content
Participative Web and User-created content

Building Confidence
Development of Policies for Protection of Critical Information Infrastructures
Malicious Software (Malware): A Security Threat to the Internet Economy
Combating On-line Identity Theft
Mobile commerce

A Global Information Economy
Global Opportunities for Internet Access Developments

Analytical background papers are available at www.oecd.org/sti/ict

Yearbook on Productivity 2008

This is the fourth Yearbook on Productivity published by Statistics Sweden. It contains nine different articles:

ICT investment, ICT use and productivity

ICT use, broadband and productivity

Does ICT-use improve your career?

Developing and implementing a survey on intermediate consumption for the service sector in Sweden

Measurements of ICT Investments/ expenditures within Statistics Sweden

Time series in the Swedish national accounts

Measuring process for ICT goods and services in Sweden

ICT impact assessment by linking data across sources and countries

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