ICT use, broadband and productivity

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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:

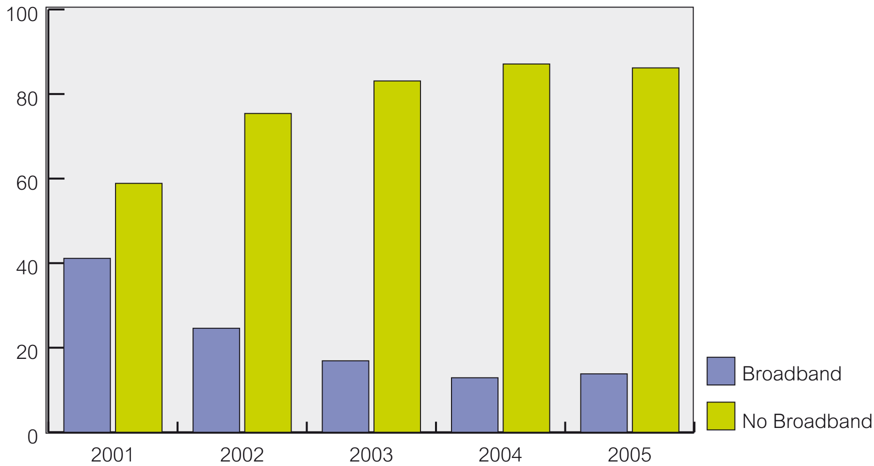
Intranet	If the companies have Intranet, 0/1 dummy
Extranet	If the companies have Extranet, 0/1 dummy
LAN	If the companies have Local Area Network, 0/1 dummy
WLAN	If the companies have Wireless Local Area Network, 0/1 dummy
PersInt	Share of employees with Internet connection

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-ITLevel0405 = dspeed05 + x04 + ε

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) $q_i = \alpha_T t_i + x_{3i}b_3 + u_{3i}$ 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 x k_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.