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Christina Håkanson

JUNE 2009

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Christina Håkanson†

Sveriges Riksbank Working Paper Series
No. 230

June 2009

Abstract

An increasing use of IT facilitates firms to use more efficient organizational forms. Significant reorganizations of business processes around IT capital can thereby boost productivity growth. The aim of this study is to empirically examine how firm productivity growth is affected by organizational changes and investments in IT using a Difference-in-Difference approach on a panel of Swedish firms over the years 1997-2005. The empirical results show a positive and significant effect on total factor productivity growth for firms that invested above median in IT and at the same time undertook organizational changes.

Keywords: information technology, productivity, organizational change
JEL codes: D24, E22, L22, 033

*I'm grateful for comments by Erik Mellander, Per Krusell, Vivek Ghosal, Mikael Carlsson, Anna Sjögren, Ettore Panetti and seminar participants at the Riksbank conference "Understanding and Predicting Productivity Growth", Nov 2007. I thank The Research Institute of Industrial Economics for letting me use the Plan Survey data and Handelsbanken's Research Foundation and the Riksbank for financial support. The views expressed in this paper are solely the responsibility of the author and should not be interpreted as reflecting the views of the Executive Board of Sveriges Riksbank.

†Institute for International Economic Studies, IIES. Email: christina.hakanson@iies.su.se

1 Introduction

There is a growing literature emphasizing that productivity gains from investments in IT hinges on simultaneous investments in complementary activities such as the use of more skilled labor in production and investment in organizational capital.[1] An increasing use of IT facilitates firms to use more efficient organizational forms. Hence, significant reorganizations of business processes around IT capital can thereby boost productivity growth.

The aim of this paper is to study the effects of organizational changes on firm productivity, taking into account interaction effects from IT. The motivation is twofold. First, the empirical studies in this field have primarily used data on reorganizations during the late 80's to the mid 90's, a period when, even though lsizeable IT investments were made, the firms to a large extent operated with "double systems", bringing IT into the old organization and old business processes. This study use more recent data, reorganizations in Swedish firms around the year 2001, when large IT stocks were already in place and used in the firms in a much more integrated way. Second, the existing empirical evidence is inconclusive and concentrated to only a few countries: the US, the UK and some studies for France. One reason for the limited work available is the requirements on data. Both data on IT investments, economic performance and organizational change is needed, preferably over several years. In particular, data on organizational change are scarce. This paper uses the, to my knowledge, only existing recent survey data on organizational changes available in Sweden, where also the hierarchical structure is addressed.[2] The "Plan Survey" is administered by the Confederation of Swedish Enterprises and the Research

[1] The Skill Biased Technical Change literature is by now very large; see for instance Krusell, Hornstein, and Violante (2004) or Draca, Sardun, and Van Reenen (2006) for an overview and Brynjolfsson, Hitt, and Yang (2002) on investments in organization and IT.

[2] The Swedish Riksbank together with Statistics Sweden have recently collected data on organizational change similar to those used in this study but for the year 2005. However, as data only become available with a time lag of two - three years it will be necessary to wait some time before the effects of these changes can be evaluated.

Institute of Industrial Economics. For this study a cross-section from the 2003 wave is matched with Structural Business Statistics and registry data on labor composition and wages, yielding a panel over the years 1997-2005. Using a difference-in-differences approach, with organizational changes as the treatment, the empirical results suggest a sizable positive effect on TFP growth for firms that *at the same time* as they undertook changes in organization also invested more than the median firm in IT.

There are a number of reasons why it is interesting to study the link between new technology, organizational change and productivity in a Swedish setting. Swedish productivity has had a similar development as in the US, i.e., quite different from that in the rest of Europe. However, Sweden differs from the US in that, alike the rest of Europe, Sweden has strict labor market regulations. Despite these regulations, Sweden however, scores high in cross-country comparisons of workplace practices and various measures of decentralization of the firm, making it an interesting testing ground.

The paper is organized as follows: Section 2 gives a background discussion and a review of the related literature. Section 3 describes the theoretical framework, motivating the interactions between organizational changes an IT. Next, in section 4, the empirical strategy is presented. In section 5 data is described along with definitions of key variables and descriptive statistics. The empirical results are presented in section 6 and section 7 concludes.

2 Background

Over the last two decades, the main direction of organizational changes has been towards flatter organizations with a more decentralized decision-making, resulting in more multi-tasking and greater responsibilities for the employees. Lindbeck and Snower (2000) point to advances in information technology, increased versatility of capital equipment, widening of human capital across tasks and changes in workers' preferences as the driving forces. Aghion, Caroli, and García-Peñalosa (1999) argue that skilled labor is complementary, not only to

technical progress, but also to contemporary reorganizations. Skilled employees are assumed to cope better with multi-tasking and increased responsibility, thus the demand for this type of labor increases. Acemoglu et al. (2007) show, in an endogenous growth model, that the closer a firm is to the technological frontier, the higher is the relative importance of innovation and therefore the more likely a firm is to adopt a structure with decentralized decision making. Yet another reason for the delayering of organizations is found within the "high performance work organizations" literature. Firm performance and productivity can be improved by means of continuous education of the employees, delegation of authority and incentive pay, cf. (Kling (1995)). In a different approach, Garicano and Rossi-Hansberg (2006) model knowledge hierarchies and show that falling prices of IT leads to flatter organizations, whereas falling prices of communication has the opposite effect. This is an interesting feature, as it creates a balanced relationship where the optimal organization hierarchy is determined by the technology mix, i.e., it is not only flattening reorganizations that can boost productivity.

There is a small but growing body of empirical evidence. Most studies however, employ organizational data from mid 1980's to mid 1990's. Bresnahan, Brynjolfsson, and Hitt (2002) argue that higher levels of technology are associated with increased delegation of authority to individuals and teams and higher levels of skill and education in the workforce. They find empirical support for complementarity between technology skill and organization of work on US data. Black and Lynch (2001) estimate augmented production functions on US firm level data 1987-1993 and relate the firm-specific residual to measures of workplace practices, human capital investments and computer usage. They find that the proportion of non-managerial workers using computers has a positive effect on productivity, as has the average educational level. They also find that firms with a larger share of younger capital have a higher than average productivity. Concerning workplace practices, their results suggest that it is not whether an employer adopts a particular practice or not that plays a role, but rather how that workplace practice is implemented. In a companion paper (2004) the same

authors study two cross sections of US firms on later data (1993-1996), but do not find support for an interaction between workplace practice and IT. Caroli and Van Reenen (2001) examine complementarity between skills and reorganization and find that a reorganizations (in the direction of more decentralized decision making) lead to a lower demand for low skilled labor. They also find that a falling relative price on high-skilled labor increases the probability for a firm to reorganize and that the largest effects on productivity are in organizations with a large proportion of high skilled labor. However, they find no evidence of an interaction between IT and organizational change.

In a different strand of the literature the effect of organizational capital on productivity is studied indirectly via ownership. In a recent paper, Bloom, Sadun, and Van Reenen (2007) find support for complementarity between IT and organizational capital studying a large sample of British firms in (1995-2004). When comparing the returns for US multinationals and statistically similar UK firms they find that US multinationals in the UK are more productive than similar UK firms. They argue that the reason for this productivity difference is that US multinationals export their organizational capital also to their foreign affiliates. Similar results have been documented for Swedish firms; Karpaty (2007) finds an increase of 3-11% in productivity from foreign acquisitions on Swedish firms (1986-2002).

The choice of both investment in organizational changes and in IT is *likely* to be endogenous. Some attempts have been made to estimate the probability of organizational change. Crespi, Criscuolo, and Haskel (2007) find that a change in competition, measured as lagged changes in market share, is negatively related to the probability of organizational change, i.e., firms that are losing market shares are more likely to reorganize in the following period. They also find that exporting firms have a significantly higher probability of organizational change, possibly due to their facing higher competitive pressure compared to locally active firms and that foreign ownership significantly increases the probability of introduce reorganizations. One way to explain this is that organizational knowledge and/or concepts are exported to the foreign affiliates, consistent with the

story in Bloom, Sadun, and Van Reenen (2007). Caroli and Van Reenen (2001) also estimate the probability of organizational change and find that higher wage inequality, proxied by regional educational wage differentials, is associated with a significantly lower probability of organizational change. Their interpretation is that a short supply of skilled workers drives up relative wages, making fewer organizational changes profitable.

3 Theoretical framework

From a theoretical point of view it's straightforward to think of relationship between investments in IT, organizational changes and productivity in terms of embodied and disembodied technical change. More specifically, how is productivity growth affected by embodied and disembodied technical change, directly and via interaction effects? To benefit from embodied technical change firms need to make physical investments - the new technology is *in* the machine. In this study embodied technical change will be represented by investments in IT capital. Disembodied technical change, on the other hand, is typically free and available for everyone. We can think of innovations in organizational technology as being disembodied technical change; as new organizational practices are introduced, they are in principle available free of charge. However, this does not mean that investments in organization come for free. On the contrary, organizational change typically induce large costs due to forgone production during the adjustment process. To allow for inputs to be complementary in production a translog production function is employed.[3] This would take into account both direct and interaction effects of organizational change and other inputs of production.

Following Gunnarsson, Mellander, and Savvidou (2004), TFP is computed

[3] See Christensen, Jorgenson, and Lau (1973) on the Translog production function.

as the ratio of deflated value added and a Törnquist index of inputs X_k:

$$TFP_t = \frac{Q_t}{f(X_{1,t}, X_{2,t}, ..., X_k, t)}$$

The Törnquist index corresponds to the translog production function and allows for complementarity between inputs. TFP growth is then computed as the difference in natural logarithm of TFP according to:

$$\Delta \ln TFP = \Delta \ln Q - \Delta \ln X_t \tag{1}$$

where $\Delta \ln X_t$ is the growth of aggregated input, each input being weighted by its average cost share.

$$\Delta \ln X_t = \sum_k \overline{\omega}_{k,t} \Delta \ln X_{k,t}$$

$P_{k,t}$ is the price of input k at time t and $\overline{\omega}_{k,t}$ is the average cost share of input k at time t according to:

$$\overline{\omega}_{k,t} = \frac{1}{2}\left(\frac{P_{k,t-1}X_{k,t-1}}{\sum_k P_{k,t-1}X_{k,t-1}} + \frac{P_{k,t}X_{k,t}}{\sum_k P_{k,t}X_{k,t}}\right)$$

4 Empirical strategy

In order to capture the effect of organizational changes on productivity growth one has to consider what would have happened, had the firms not undertaken organizational changes - the counterfactual situation. Since firms only can be observed in one state - they either did or did not make organizational changes - the counterfactual has to be constructed synthetically. The strategy chosen in this paper is to adopt a difference-in-differences approach using organizational changes as treatment. By comparing the change in outcomes for a group of treated firms (that made organizational changes) with that of control firms (that didn't make any organizational changes) one hopes to isolate the effect. The difference-in-differences estimator is an unbiased estimate of the causal effect if, absent the treatment, the average change in TFP growth would have been

the same for the treatment and control groups (the parallel underlying trend assumption). However, reorganizations are ineffect not randomly assigned, so a bias cannot be ruled out. It is therefore important to explicitly consider potential bias due to nonrandom sampling, i.e., we would like firms to be, ex ante, as statistically similar as possible. One way of ensuring this is to first pair up treated and untreated (control) firms using a matching estimator. On this small panel however, the number of observations is simply too few to make such matching. Instead, to evaluate the composition of the two groups, pretreatment characteristics are examined.

The basic difference-in-differences setup is shown in equation (2):

$$\Delta tfp_{it} = c + \theta_1 T_{it} + \theta_2 \Delta O_{it} + \theta_3 (T_{it} * \Delta O_{it}) + \boldsymbol{\eta}'_{it}\boldsymbol{\omega}_{it} + \upsilon_i + \varepsilon_{it} \qquad (2)$$

where T is the time effect, a dummy which takes the value 0 in the years 1997-2001 (the years before the organizational change) and 1 after that. Note that in the survey data there is no information on the exact date the organizational changes took place; instead the data picks up organizational changes "during the last three years" (meaning 2000-2002). In the empirical analysis organizational changes are placed in the middle of this interval (i.e., 2001).[4] Continuing, ΔO is the group dummy indicating whether a firm is part of the treated group (i.e., undertook organizational changes) or not. The coefficient of interest, the difference-in-differences estimator, is θ_3 which captures the effect of being part of the treated group in the "after" period. $\boldsymbol{\omega}_i$ is a vector of other controls such as industry, firm size, labor composition etc. These are included to reduce compositional bias, i.e., to control for observable differences between the observations in the different groups. Finally, υ_i is a time invariant, firm specific effect and ε_{it} is the idiosyncratic component of the error term.

To take the link with investments in IT into consideration equation (2) is modified in the following way: both the group effect, θ_2, and the difference-in-

[4] Another way could be to simply eliminate the years 2000-2002 and apply the DiD estimator on that sample. The results are qualitatively robust to this. However, considering the limited amount of data that is available to start with the former approch is kept.

differences effect, θ_3, are interacted with dummies indicating the intensity of IT investments. Changes in organizations can happen for all sorts of reasons and in order to focus on those made in connection to investments in IT this interaction estimates the effect of organizational change is separately for firms that have zero, low and high levels of IT investments. The estimated equation becomes:

$$\begin{aligned}\Delta tfp &= c + \theta_1 T + \theta_2^{zero}(\Delta O * IT^{zero}) + \theta_2^{low}(\Delta O * IT^{low}) \\ &\quad + \theta_2^{high}(\Delta O * IT^{high}) + \theta_3^{zero}(T * \Delta O * IT^{zero}) \\ &\quad + \theta_3^{low}(T * \Delta O * IT^{low}) + \theta_3^{high}(T * \Delta O * IT^{high}) \\ &\quad + \boldsymbol{\eta}_i' \boldsymbol{\omega} + \upsilon_i + \varepsilon_{it} \end{aligned} \tag{3}$$

The key identifying assumption are that the time effect T captures how both the treatment and control group are influenced by time and that the fixed group effect $(\Delta O * IT^j)$ captures any fixed unmeasured differences between the two groups, such that there is no interaction between the time effect and the treatment group effect, i.e., $E(\varepsilon \mid (T * \Delta O * IT^j)) = 0$. Given the structure of the data it is not obvious that this is true. The choice of both investing in organizational changes and in IT is *likely* to be endogenous. A weakness in this setup is that this choice is not modeled; organizational changes are treated as if they were exogenously given (as are investments in IT). Ideally we would like to have some exogenous mechanism determining the choice.

For the sample period studied here the economic downturn possibly created a strong pressure for transformation which may have affected the timing of organizational changes, but there is still likely to be selection into which firms decide to make changes in the organization. To assess factors previously identified to explain the probability of organizational change, the following probability equation is estimated, using indicators similar to those used by Crespi, Criscuolo, and Haskel (2007):

$$\Delta O = c + \kappa_1 \Delta share + \kappa_2 F + \kappa_2 \Delta hs + \boldsymbol{\gamma}_i' \mathbf{n} + \epsilon \tag{4}$$

where ΔO is the 0/1 indicator for organizational change, $\Delta share$ is the lagged change in industry market share, F is dummy variable indicating whether the firm is exporting, Δhs is the lagged change in share of high skilled employees and $\mathbf{n}$ is a vector of basic controls, such as industry and size. This, however, only addresses half of the problem as it is the decision to *both* invest in organizational changes *and* in IT that is of interest. The ideal would be to measure only organizational changes explicitly connected to IT investments and estimate the probability of that event but the data at hand does not allow for that. The estimated coefficients are all insignificant, but the results are included in the appendix for reference.[5]

5 Data

5.1 Sources of data

It is hard to find firm level panel data on performance, inputs, IT and organizational change. The panel used in this study is created by matching multiple sources of data. The observational frame consists of the firms that participated in the Plan Survey 2003, a survey administered by the Confederation of Swedish Enterprises and the Research Institute of Industrial Economics. The Plan survey is a rotating panel survey covering mostly large firms or, more correctly, large workplaces in the Swedish manufacturing sector, and from the year 2000 onwards, also firms within the service sector. The survey is not representative, instead the aim has been to cover as much as possible of the Swedish business sector with a limited amount of observations. Accordingly more than 90 percent of the firms covered have at least 100 employees. In the year 2003 a question was also asked regarding the general hierarchical structure of the firm, i.e., how many staffing and manning levels they currently had and whether the number

[5] Another way to solve the endogeneity problem is to instead find an instrument for organizational changes. In a larger data set indicators such as changes of CEO or mergers and aquisitions could be possible candidates. But again, measuring the joint decision of IT and organizational change is impairative to fully adress the endogeneity problem.

of hierarchical levels had changed. In addition questions indicating indirect organizational changes were asked. The companies were asked to state whether, for a majority of their employees, the number of tasks and/or the amount of responsibility had increased, decreased or remained unchanged. These question were all designed to match those used in Caroli and Van Reenen (2001).

The cross section of the 2003 wave is matched with two sources of economic register data from Statistics Sweden to build up a panel with "before" and "after" years around the organizational changes.[6] Value added, gross and net investments in buildings, machinery, equipment and other detailed accounting information is matched from the Structural Business Statistics. From the register database LISA, a longitudinal database compiled by Statistics Sweden covering every Swedish resident over 15 years of age over the years 1990 and onwards, information about wages and labor composition was added. The matching process resulted in a small but rich panel of 120 firms followed over nine years: 1997-2005.[7] Given the limited sample size, generalizations of the empirical analysis have to be made with caution.

5.2 Key variables

In what follows the key variables of the analysis, *Organizational Change,* ΔO and the different measures of the level/intensity of IT investment are presented. In appendix A the full set of variables and controls are described.

Organizational Change, ΔO

[6] The matching required the permission of each firm. Formal requests were sent out during spring of 2007, followed by e-mail reminders. Finally, the remaining firms were contacted by phone. Out of the 192 firms, 75% gave permission to match data, 5% had changed structures to the extent that they were not meaningful to track. Only 5 firms, or 2.5% denied the request to match data. The remaining firms could, in spite of large efforts, not be reached. Out of the 144 firms who gave permission we were able to successfully match 136. The estimation sample is further reduced to 120 companies due to restrictions on data as some firms lacked information on investments in IT.

[7] Appendix A further describes the different sources of data, the matching process and the complete set of variables and their definitions.

Organizational change is measured by three questions included in the 2003 wave of the Plan Survey. The questions were designed to parallel some of those in Caroli and Van Reenen (2001). In Table 1 each of the questions is presented along with the distributions of answers. For about twenty percent of the companies, the number of staffing and manning levels had changed. Compared to Caroli and Van Reenen (2001), henceforth CVR, much fewer companies indicated decreased number of staffing and manning levels (only 9 % compared to almost 35% in CVR). Interestingly, glancing at the data collected by Statistics Sweden and the Riksbank for 2004-2005, about twice as many indicated that they had *increased* staffing and manning levels in the firm.[8] This can indicate that the trend of continuous decentralization may have changed in Sweden. For the other two indicators, the distributions of answer were much more similar to those in CVR. Areas of responsibility connected to specific positions had increased in 55% of the cases. Only 2% reported a decrease (the figures were 46% and 3% respectively in CVR). This pattern also holds when looking at range of tasks connected to specific positions. In 45% of the cases, the number of tasks had increased and in only 5% the number of tasks had decreased (compared to 63% and 6% respectively in CVR).[9] Hence, the majority of organizational changes were in the direction of flatter, more decentralized decision making, even though compared to CVR the actual delayering was less pronounced.

As the main hypothesis is that increased use of new technology, IT and communications, open up opportunities for more efficient ways of organizing, the direction of the organizational change can differ depending on industry and firm-specific technological mix. In the empirical analysis organizational change is

[8] 2006 the Riksbank arranged for data on organizational change to be collected within the survey "IT, work organization and productivity" from Statistics Sweden. The new data covers the same indicators on organizational changes as used here but during the period 2004-2005 and in a representative sample of 2015 Swedish firms. This study thus serves as a pilot study.

[9] In CVR these questions were asked for non-manual and manual workers separately. The comparison made here regards the answers of non-manual workers. The corresponding figures for manual workers are 33% more and 6% less responsibility, 40% more and 13% less tasks and 11% more and 46% fewer staffing and manning levels.

therefore represented by a dummy variable which takes the value 1 if a company reported at least two instances of organizational change (regardless of direction) and 0 otherwise.[10] This occurs in 55 cases. As it turns out, the vast majority (69%) of the these are indeed in a direction flatter. 27% had mixed indicators and only 4% had purely changes that indicate an increase in hierarchy.

Technology, IT

There is no information on investments in IT within the Structural Business Statistics; hence it is not possible to follow the evolution of the stock of IT capital.[11] However there is information on investments in IT within the Plan Survey for the years 2001-2003. Using this data, four different measures of IT investments, made *in connection* (same time period) with the organizational changes, are constructed.

It is not obvious how to measure IT investments. A classic procedure is to measure IT intensity as investments in IT relative to total investments. This would reveal the technology mix in a firm. But you can also make an argument for different measures. Consider a firm with very large investments in real capital, for instance in the paper and pulp industry. As an example, an installation of automatic computer surveillance in the production process here can give very large effects on productivity as the length of production stops is significantly shortened. However the investment relative to total investments will be minor. Here IT investments relative to the number of employees might be a better measure. Also, it is natural to think of the investment in IT relative to number of employees when looking at interactions with organizational change

[10] The motivation for allowing all directions of organizational change comes from Garicano and Rossi-Hansberg (2006), i.e., allowing for the possibility that a technological mix with a lot of communication capital might push firms towards a more hierarchical structure. In the empirical analysis experiments are also made restricting the ΔO dummy to be one only if firms reported at least two organizational changes in the direction of flatter. This does not change any of the results notably. If anything, the effects are stronger using the wider definition.

[11] Statistics Sweden used to cover investments in IT, but the series was discontinued in 1994. They have now decided to resume this data collection. The first survey was conducted in the fall of 2006.

Table 1: Indicators of Organizational Change

Have areas of responsibility connected to specific positions changed in the period 2000-2002?		CVR	
	All	non-manual workers	manual workers
yes, increased	55%	*46%*	*33%*
no	43%	*47%*	*57%*
yes, decreased	2%	*3%*	*6%*
Have the range of tasks connected to positions changed in the period 2000-2002?			
yes, increased	45%	*63%*	*40%*
no	50%	*28%*	*45%*
yes, decreased	5%	*6%*	*13%*
Have the number of staffing and manning levels changes in the period 2000-2002?			
yes, increased	10%	*9%*	*11%*
no	81%	*55%*	*42%*
yes, decreased	9%	*35%*	*46%*

- since people define organizations. I will here make use of 4 different measures of the intensity of IT investments, the first two relating investments in IT to the number of employees and the last two relative to total investments. The main focus will be on the first measure (A) which categorizes firms into three different groups, IT^{zero}, IT^{low} and IT^{high}, depending on their maximum investment in IT per employee during the period of organizational change (2000-2002). The IT^{zero} firms reported zero investments in IT per employee for the period where organizational changes took place. $IT^{low(high)}$ firms reported below (above) median investment in IT per employee.[12] The division partitions both the sample as a whole and the sub-sample that carried through organizational changes into groups of fairly equal size. Next, as a sensitivity check, instead of using the maximum investment, the average investment (same period) in IT per employee is considered (B). This will decrease the impact of any one time large investment. In measure C (D) the focus is switched to the classic intensity of IT investments, looking at the maximum (mean) share of IT investments to total investments. In C and D, instead of having zero investment as a group, the cutoffs are set at the 33th and 67th percentile to get equal group sizes. Note that the same variable names will be used for all four measures in the estimations. The IT measures are indicated by the letters A,B,C and D in the results.

Looking at the correlation between the different measures it is worth pointing out that many of the firms in the $IT^{high}-$group change quite a lot using the different measures: about 30% of the firms are exchanged going from measure A to measure C. The correlation is 0.45 in the total sample and 0.63 within the group that made organizational changes (see table 2). Also the industry mix changes the $IT^{high}-$group; the $IT^{high}-$group is more concentrated to the business services sector (i.e., consultants etc.) using measure C. Within this sector sometimes IT is the only capital investment.

[12] The cutoff value was set to the median of the firms that reported non zero investment levels in IT.

Table 2: Correlation for the different measures of IT

	$IT_A^{high}=1$	$IT_B^{high}=1$	$IT_C^{high}=1$	$IT_D^{high}=1$
$IT_A^{high}=1$	1			
$IT_B^{high}=1$	0.84	1		
$IT_C^{high}=1$	0.41	0.41	1	
$IT_D^{high}=1$	0.45	0.45	0.92	1
	$\Delta O * IT_A^{high}=1$	$\Delta O * IT_B^{high}=1$	$\Delta O * IT_C^{high}=1$	$\Delta O * IT_D^{high}=1$
$\Delta O * IT_A^{high}=1$	1			
$\Delta O * IT_B^{high}=1$	0.81	1		
$\Delta O * IT_C^{high}=1$	0.59	0.65	1	
$\Delta O * IT_D^{high}=1$	0.63	0.69	0.91	1

IT measures: A max [investment in IT /employee]; B mean [investment in IT /employee];
C max [investment in IT /total investments]; D mean [investment in IT /total investments]

5.3 Descriptive statistics and comparison of samples

As organizational change is not randomly assigned, first basic characteristics of the different groups is compared. The data is divided according to organizational change and IT investments using measures A and C.[13] Table 3 displays the distribution over broad industries.[14] Although the final panel used is very small it covers firms within many industries in the Swedish private sector. Out of the 120 companies, about 59% are from the manufacturing sector and 41% from the service sector. The distribution over industries does not vary substantially between the treatment and the control groups.

Table (4) show summary statistics for the total sample, firms that undertook organizational change, and firms that both reorganized and invested above median in IT, respectively. A couple of remarks are in order. As mentioned, the Plan Survey over-samples large firms. This is apparent in the distribution of the firm size category variables: two thirds of the sample are firms with more than 100 employees and about half the sample are firms with more than 250 employees. The distribution of firm sizes does not differ much between firms that only reorganized or reorganized and invested above median in IT, compared to the total sample. In fact, the samples are quite similar with regard to employee composition and firm characteristics. Looking at the distribution over the three IT categories, a quite large fraction of firms report zero investment: 23% in the total sample and 27% among those who underwent organizational change. However, this does not imply that they are low tech-firms; rather, they simply did not do any IT investments during the time window where the organizational change was measured.

To further compare the groups, in table 5 the mean of pre treatment characteristic variables are compared for the control group, the group that undertook organizational change and the group that in addition to making organizational

[13] The other two measures of IT give similar results.

[14] The Swedish Standard Industrial Classification is coordinated with the European NACE (Nomenclature statistique des Activités économiques dans la Communauté Européenne) up to the 4-digit level.

Table 3: Descriptive statistics: distribution over industries

	$NACE$	All $n = (120)$	$\Delta O = 1$ $(n = 55)$	$\Delta O * IT_A^{high} = 1$ $(n = 22)$	$\Delta O * IT_C^{high} = 1$ $(n = 21)$
Agriculture, fishing and forestry	$1 - 2$	1%	0%	0%	0%
Food products, textiles	$15 - 19$	6%	7%	9%	5%
Pulp, paper and paper prod.	21	10%	9%	5%	0%
Chemicals, non-metallic prod.	$23 - 26$	9%	9%	0%	0%
Basic metal and metal products.	$27 - 28$	13%	13%	22%	19%
Mach. and equip., instruments	$29 - 36$	21%	22%	23%	19%
Constr.,wholesale, retail, hotel.	$45 - 55$	6%	4%	0%	5%
Transport storage and comm.	$60 - 64$	12%	9%	5%	10%
Real estate, renting	$70 - 71$	8%	7%	9%	5%
Business activities	$72 - 74$	16%	20%	27%	37%

Table 4: Descriptive statistics

Variable	$\Delta O = 0, n = 449$		$\Delta O = 1, n = 383$		$\Delta O * IT_A^{high} = 1, n = 148.$		$\Delta O * IT_C^{high} = 1, n = 150.$	
	Mean	*Std.Dev.*	*Mean*	*Std.Dev.*	*Mean*	*Std.Dev.*	*Mean*	*Std.Dev.*
tfp	5.911	1.499	6.075	1.258	6.029	1.701	6.480	0.561
Δtfp	0.067	0.364	0.035	0.373	0.070	0.359	-0.016	0.376
labor productivity (ln)	6.463	0.630	6.360	0.563	6.528	0.584	6.173	0.368
Δlabor productivity	0.023	0.331	0.011	0.308	0.012	0.322	-0.005	0.365
IT_c	0.300	0.342	0.340	0.377	0.519	0.367	0.746	0.266
IT_A	0.016	0.021	0.014	0.016	0.028	0.016	0.024	0.018
IT_D	0.211	0.276	0.262	0.332	0.400	0.329	0.589	0.304
IT_B	0.010	0.013	0.009	0.012	0.020	0.012	0.016	0.014
share of employees:								
high skilled	0.249	0.195	0.245	0.192	0.288	0.211	0.306	0.231
intermediate skilled	0.485	0.121	0.513	0.128	0.478	0.120	0.515	0.164
low skilled	0.267	0.137	0.242	0.119	0.233	0.129	0.179	0.115
edu. in engineering	0.409	0.191	0.390	0.198	0.422	0.195	0.402	0.233
edu. in economics, business adm, law	0.135	0.105	0.156	0.097	0.163	0.086	0.190	0.122
other education	0.456	0.178	0.454	0.159	0.415	0.144	0.408	0.153
age -29	0.254	0.159	0.262	0.149	0.219	0.128	0.285	0.192
40-49	0.462	0.099	0.468	0.093	0.484	0.106	0.483	0.126
50-	0.303	0.121	0.293	0.123	0.313	0.116	0.250	0.133
immigrants	0.140	0.105	0.139	0.105	0.126	0.075	0.106	0.069
females	0.278	0.172	0.305	0.198	0.277	0.165	0.329	0.229
number of employees	862	2362	533	957	362	362	417	423.653
share of companies in IT_A^{zero}	0.194	0.396	0.272	0.445				
share of companies in IT_A^{low}	0.430	0.496	0.342	0.475				
share of companies in IT_A^{high}	0.376	0.485	0.386	0.488				

change also invested above median in IT. T-tests with $H_0 : \mu_{\Delta O=0} = \mu_{\Delta O=1}$ and $\mu_{\Delta O=0} = \mu_{\Delta O * IT_A^{high}=1}$, respectively, are included.

In most aspects the firms that made organizational changes is very similar to those who did not. Still, some differences are worth pointing out: firms that undertook organizational change on average had a higher share of employees with intermediate skills (significant at 5% level) and were on average smaller (significant at 10% level). On average they also had lower productivity growth, however, this difference is not significant. The group that also made large investments in IT ($\Delta O * IT_A^{high} = 1$) and also had a lower productivity growth, the difference now weakly significant, and were less represented among the largest firms (significant at 5% level). Another difference is that this group had a significantly lower share of immigrants among the employees (by about three percentage points), which might be an indication that language and communication could be important in determining the likelihood of organizational change.

To sum up, there are some statistically significant differences between the treatment and the control group. However, the distributions industry and employee characteristics are fairly similar. The treatment and control group also have a similar pattern of TFP (and labor productivity) growth before treatment. Together this gives some support for the parallel trend assumption.

6 Results

Table 6 shows the results from estimating equation (3). The number of observations in the baseline estimation is 832, yielding an average of 6.9 observations (out of maximum 8) per firm. All regressions have standard errors clustered at firm level, a constant and control for size firm (number of employees). A full set of two-digit industry dummies is also included, unless a fixed effect estimator is used. The first column reports the results from the baseline regression with no additional controls. The result is quite striking: the group of firms that both undertook organizational change and made large investments in IT had a

Table 5: Comparison of means pretreatment

variable	$\Delta O = 0$	$\Delta O = 1$	$\mu_{\Delta O=0} = \mu_{\Delta O=1}$	$(\Delta O * IT_A^{high} = 1)$	$\mu_{\Delta O=1} = \mu_{\Delta O * IT_A^{high}=1}$
tfp	5.67	5.90	(-1.00)	5.68	*(-0.05)*
Δtfp	0.15	0.09	(1.15)	0.07	*(1.35)**
labor productivity (ln)	6.37	6.31	(0.81)	6.52	(-1.43)*
Δlabor productivity	0.004	-0.02	(0.69)	-0.06	(1.14)*
share of employees:					
high skilled	0.23	0.21	(0.90)	0.23	*(0.04)*
intermediate skilled	0.47	0.51	$(-2.29)**$	0.48	*(-0.05)*
low skilled	0.30	0.28	(0.64)	0.29	*(0.31)*
edu. in engineering	0.40	0.37	(0.87)	0.42	*(-0.50)*
edu. in economics, business adm, law	0.16	0.18	(-1.25)	0.16	*(-0.16)*
other education	0.45	0.45	(0.00)	0.42	*(0.73)*
age -29	0.28	0.29	(-0.83)	0.24	*(1.04)*
40-49	0.46	0.46	(0.29)	0.46	*(0.11)*
50-	0.28	0.27	(0.67)	0.31	*(-1.5)**
immigrants	0.28	0.31	(-1.02)	0.27	*(0.51)*
females	0.14	0.13	(0.36)	0.11	*(1.72)***
number of employees	739	474	$(1.46)*$	376	*(2.11)***

Pretreatment means are compared using observations for the years 1998 and 1999.
Test for equal mean, t-statistics within parenthesis, *** p<0.01, ** p<0.05, * p<0.1
$\Delta O = 0$ refers to the group that did not do any organizational change
$\Delta O = 1$ refers to the group that made organizational change
$\Delta O * IT_A^{high} = 0$ refers to the group that made organizational change and made large investments in IT]
IT measure A: max [investment in IT /employee

18.3 percentage points increase in TFP growth. The result is significant at the 1% level. Interestingly, there were no significant effects for the firms with the other two groups of IT investment, supporting the hypothesis that it is indeed organizational changes combined with increased IT-capital that has an effect on productivity growth.

A concern in the difference-in-differences setup is that there may be other interactions between the treatment group and time. One indication of this is that the regression shows a large time effect, θ_1. Since θ_1 picks up the effects of omitted variables and trends in the dependent variable, a large θ_1 would suggest that the effects from these sources vary substantially between treatment and control group and that there are likely to be omitted variables. On the other hand, if the time effect, θ_1, and the group effects, θ_2^{zero}, θ_2^{low}, θ_2^{high}, are small and statistically insignificant it is instead an indication that the treatment and control group indeed share the same trend prior to the policy change.

The time effect is indeed significant in the first column. One possible reason can be that the timing of the treatment period incidentally coincided with a very sharp turn in the business cycle year 2001. Therefore, in column (2) and onwards, a third degree polynomial (TREND) is included to control for general business cycle movements. This renders the time effect insignificant, but leaves the other estimates unchanged. The group effects are in general insignificant, except for the group effect of low IT, which is significant at the 5% level, in the first two regressions. Column (3) repeats the baseline regression by using a fixed effect estimator. The point estimate for θ_3^{high} increases marginally whereas the significance is unchanged.

If selection into the treatment groups is correlated with the outcome, we would see changes in the estimates as a result of including more controls. In column (4) extra controls for employee composition are included: skill levels, field of study, age, share of females and the share of immigrants among the workers.[15] The choice of controls is motivated by endogenous growth theory, which predicts that productivity growth is determined by levels of inputs, such

[15] All extra controls are lagged one period.

Table 6: Results: Difference-in-Difference estimations of equation (3).

dep. variable		(1) dtfp	(2) dtfp	(3) dtfp	(4) dtfp	(5) dtfp	(6) dtfp	(7) dtfp	(8) dLP	(9) dLP
T	θ_1	-0.0809**	-0.0226	-0.0163	-0.0195	-0.0263	0.0504	0.0430	-0.0386	-0.120
		(0.0330)	(0.0891)	(0.0870)	(0.0900)	(0.0902)	(0.104)	(0.106)	(0.0303)	(0.0870)
$(\Delta O * IT^{zero})$	θ_2^{zero}	0.0261	0.0245		-0.0196		0.0225		-0.0167	
		(0.0506)	(0.0514)		(0.0644)		(0.0825)		(0.0349)	
$(\Delta O * IT^{low})$	θ_2^{low}	-0.0978**	-0.0977**		-0.0502		-0.0812		-0.00799	
		(0.0479)	(0.0479)		(0.0504)		(0.0669)		(0.0399)	
$(\Delta O * IT^{high})$	θ_2^{high}	-0.0774	-0.0770		-0.0414		-0.0391		-0.0693*	
		(0.0473)	(0.0475)		(0.0517)		(0.0589)		(0.0355)	
$(T * \Delta O * IT^{zero})$	θ_3^{zero}	0.0208	0.0226	0.0392	0.0716	0.0725	0.0928	0.0986	0.0463	0.0530
		(0.0889)	(0.0894)	(0.0910)	(0.0925)	(0.0961)	(0.170)	(0.170)	(0.0703)	(0.0732)
$(T * \Delta O * IT^{low})$	θ_3^{low}	0.0359	0.0355	0.0536	0.0123	0.0334	0.0750	0.0989	0.0437	0.0153
		(0.0575)	(0.0573)	(0.0554)	(0.0477)	(0.0524)	(0.0910)	(0.0923)	(0.0480)	(0.0542)
$(T * \Delta O * IT^{high})$	θ_3^{high}	0.183***	0.183***	0.199***	0.177***	0.186***	0.192**	0.190**	0.166***	0.157***
		(0.0569)	(0.0571)	(0.0555)	(0.0592)	(0.0596)	(0.0938)	(0.0932)	(0.0508)	(0.0542)
total investment /empl					-0.000595**	-0.000603*	-0.000706	-0.000445		
share of employees:					(0.000287)	(0.000307)	(0.000426)	(0.000545)		
high skilled					0.542**	0.769	0.746**	0.471		
					(0.220)	(0.597)	(0.326)	(1.378)		
intermediate skilled					0.304	-0.467	0.500	0.650		
					(0.221)	(0.648)	(0.365)	(1.233)		
edu. in Engineering					-0.546***	0.0717	-0.736**	-0.530		
					(0.204)	(0.631)	(0.289)	(1.262)		
edu. in Econ., Bus.Adm, Law					-0.625**	-0.492	-0.816*	-0.254		
					(0.284)	(0.406)	(0.463)	(0.748)		
age -29					-0.136	-0.131	-0.224	0.785		
					(0.154)	(0.441)	(0.201)	(0.831)		
age 40-49					-0.382*	-0.172	-0.392	0.874		
					(0.223)	(0.467)	(0.357)	(0.915)		
females					-0.142	-0.375	-0.0847	0.397		
					(0.127)	(0.475)	(0.155)	(1.005)		
immigrants					0.0192	0.0315	0.184	0.949		
					(0.153)	(0.494)	(0.242)	(0.935)		
number of employees		1.33e-05***	1.39e-05***	-4.63e-06	1.91e-05***	-2.56e-05	2.44e-05***	0.000205	1.93e-06	-3.37e-05**
		(4.51e-06)	(4.47e-06)	(3.28e-05)	(5.54e-06)	(5.77e-05)	(5.81e-06)	(0.000162)	(2.71e-06)	(1.31e-05)
IND		Y	Y	Y	Y	Y	Y	Y	Y	Y
TREND		N	Y	Y	Y	Y	Y	Y	Y	Y
Fixed effects		N	N	Y	N	Y	N	Y	N	Y
Observations		832	832	832	709	709	386	386	857	857
Number of firms				120		118		97		120
Adjusted R^2		0.082	0.086	0.012	0.120	0.033	0.188	0.001	-0.006	0.002

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

IT measures: A max [investment in IT /employee]; B mean [investment in IT /employee]; C max [investment in IT /total investments]; D mean [investment in IT /total investment

as skill. Also, to rule out the possibility that large investments in drive the result, net investments in machinery & equipment per employee is included. The inclusion of these controls does not affect the size or significance of the main estimate of interest, importantly the group effect for the low IT group becomes insignificant.[16] Column (5) repeats the extended regression using the fixed effect estimator. The estimate of the effect of both investing above median in IT and undertaking organizational change, θ_3^{high}, is again only marginally affected and still significant at the 1% level.

In general, Difference-in Differences estimators are regarded as more reliable when comparing outcomes just before and just after a policy change. Yet, from a policy perspective it is also of interest to look at medium and long term effects. The problem, however, is that, as the time window increases, the treatment effect is likely to be confounded by other changes that occurred during the period. As another robustness check the regressions are therefore reestimated on a shorter panel including only the years 1999-2003, i.e., one year before and after the window for organizational change. Reassuringly, the estimates (column 6 and 7) are largely unchanged.[17] Finally, in the two last columns of table 6 instead of using tfp growth, the dependent variable is changed to labour productivity growth (log difference). The effect is now somewhat smaller, around 15-16%, but still highly significant. To sum up, the results are largely invariant to changes in specification, sample and the time period used.

To assess if the use of different definitions of intensity in IT investment affect the result, the specifications in column (4) and (5) in table 6 is reestimated using the three alternative measures IT investments described on page 13. The results

[16] In another set of regressions (not included here) even more detailed labor composition was controlled for: field of education and age was controlled for at each educational level, also the share of immigrants was split into "new" and "old" immigrants, respectively. The results were unaffected by this.

[17] Further experiments has been done taking away e.g. very large/small firms, and firms with very high/low tfp growth to see if extreem observations seem to drive the results. This is not the case, when observations with very high/low tfp growth is deleted the point estimate of the difference-in-difference for the high IT group is somewhat lower, but remains significant.

are presented in table 7.

First, instead of looking at the maximum investment in IT per employee, the average over the period is considered. This will decrease the impact of any one large investment and one could therefore expect the estimated effect to be smaller. Indeed this is the case, θ_3^{high} is still significant, but is lower in magnitude: 0.14. With the fixed-effect estimator both the point estimate increases slightly. In columns (5-6), IT intensity is instead measured as the maximum share of IT investments in total investments. The results are largely unchanged and remains significant. Finally, in the last two columns, the average investment in IT to total investments is considered. θ_3^{high} are again lower when using the average. The results in table 7 suggests that the interaction with organizational change is important both looking at IT investments per employee and IT investments to total investments. Remember that about 30% of the firms in the IT^{high} group are exchanged going from IT investments per employee (measure A) to IT investments to total investments (measure C) and the industry composition changes. The effect on productivity from organizational change and IT investments it thus no confined to a certain industry or type of firm.

7 Conclusions and final remarks

This paper takes a difference-in-differences approach to analyze effects of organizational change around the year 2001 on productivity growth. The data used is a small but detailed panel of Swedish firms that are followed over nine years: 1997-2005. The results show a sizeable positive and significant effect on productivity growth for firms that *both* undertook organizational change and invested above median in IT. No effects are found for firms that made reorganizations but had zero or low investments in IT. The results are quite robust to a variety of changes to the specification. The estimates are unaffected by shrinking the evaluation window and balancing the panel; also, they are qualitatively unaffected by the use of alternative measures of IT or the employment

Table 7: Results using different measures of IT.

IT-measure		(1) IT_A	(2) IT_A	(3) IT_B	(4) IT_B	(5) IT_C	(6) IT_C	(7) IT_D	(8) IT_D	(9) $non-IT$
dep. variable		dtfp	dtfp	dtfp	dtfp	dtfp	dtfp	dtfp	dtfp	dtfp
T	θ_1	-0.0195	-0.0263	-0.0225	-0.0277	-0.0159	0.0504	0.0430	-0.0228	-0.0492
		(0.0900)	(0.0902)	(0.0901)	(0.0903)	(0.0929)	(0.104)	(0.106)	(0.0929)	(0.0917)
$(\Delta O * IT^{zero})$	θ_2^{zero}	-0.0196		-0.0200		-0.0232	0.0225			
		(0.0644)		(0.0627)		(0.0672)	(0.0825)			
$(\Delta O * IT^{low})$	θ_2^{low}	-0.0502		-0.0742		0.0199	-0.0812			
		(0.0504)		(0.0532)		(0.0558)	(0.0669)			
$(\Delta O * IT^{high})$	θ_2^{high}	-0.0414		-0.0122		-0.0860*	-0.0391			
		(0.0517)		(0.0497)		(0.0507)	(0.0589)			
$(T * \Delta O * IT^{zero})$	θ_3^{zero}	0.0716	0.0725	0.0736	0.0736	0.0902	0.0928	0.0986	0.0902	0.113
		(0.0925)	(0.0961)	(0.0923)	(0.0955)	(0.0988)	(0.170)	(0.170)	(0.102)	(0.0690)
$(T * \Delta O * IT^{low})$	θ_3^{low}	0.0123	0.0334	0.0619	0.0672	0.0489	0.0750	0.0989	0.109**	0.113
		(0.0477)	(0.0524)	(0.0471)	(0.0507)	(0.0529)	(0.0910)	(0.0923)	(0.0532)	(0.0720)
$(T * \Delta O * IT^{high})$	θ_3^{high}	0.177***	0.186***	0.139**	0.154**	0.145**	0.192**	0.190**	0.130**	0.0987
		(0.0592)	(0.0596)	(0.0625)	(0.0619)	(0.0621)	(0.0938)	(0.0932)	(0.0639)	(0.0737)
total investment /empl		-0.000595**	-0.000603*	-0.000581**	-0.000603*	-0.000608**	-0.000706	-0.000445	-0.000608*	-0.000602*
share of employees:		(0.000287)	(0.000307)	(0.000284)	(0.000307)	(0.000300)	(0.000426)	(0.000545)	(0.000312)	(0.000311)
high skilled		0.542**	0.769	0.488**	0.728	0.506**	0.746**	0.471	0.648	0.556
		(0.220)	(0.597)	(0.217)	(0.596)	(0.225)	(0.326)	(1.378)	(0.608)	(0.640)
intermediate skilled		0.304	-0.467	0.158	-0.532	0.199	0.500	0.650	-0.566	-0.703
		(0.221)	(0.648)	(0.220)	(0.649)	(0.239)	(0.365)	(1.233)	(0.673)	(0.660)
edu. in Engineering		-0.546***	0.0717	-0.500**	0.143	-0.501**	-0.736**	-0.530	0.309	0.317
		(0.204)	(0.631)	(0.205)	(0.626)	(0.210)	(0.289)	(1.262)	(0.639)	(0.635)
edu. in Econ., Bus.Adm, Law		-0.625**	-0.492	-0.563**	-0.386	-0.484*	-0.816*	-0.254	-0.280	-0.275
		(0.284)	(0.406)	(0.282)	(0.399)	(0.281)	(0.463)	(0.748)	(0.406)	(0.394)
age -29		-0.136	-0.131	-0.118	-0.0535	-0.0952	-0.224	0.785	-0.0567	-0.00362
		(0.154)	(0.441)	(0.154)	(0.436)	(0.160)	(0.201)	(0.831)	(0.439)	(0.465)
age 40-49		-0.382*	-0.172	-0.338	-0.140	-0.285	-0.392	0.874	-0.0986	-0.0431
		(0.223)	(0.467)	(0.228)	(0.464)	(0.228)	(0.357)	(0.915)	(0.465)	(0.541)
females		-0.142	-0.375	-0.151	-0.406	-0.214	-0.0847	0.397	-0.333	-0.176
		(0.127)	(0.475)	(0.126)	(0.471)	(0.136)	(0.155)	(1.005)	(0.494)	(0.494)
immigrants		0.0192	0.0315	0.113	0.0909	-0.0846	0.184	0.949	0.0348	0.219
		(0.153)	(0.494)	(0.151)	(0.474)	(0.186)	(0.242)	(0.935)	(0.551)	(0.489)
number of employees		1.91e-05***	-2.56e-05	1.75e-05***	-2.56e-05	1.92e-05***	2.44e-05***	0.000205	-2.58e-05	-2.57e-05
		(5.54e-06)	(5.77e-05)	(6.32e-06)	(5.76e-05)	(6.19e-06)	(5.81e-06)	(0.000162)	(5.74e-05)	(5.80e-05)
IND		Y	Y	Y	Y	Y	Y	Y	Y	Y
TREND		Y	Y	Y	Y	Y	Y	Y	Y	Y
Fixed effects		N	Y	N	Y	N	Y	N	Y	Y
Observations		709	709	709	709	685	685	685	685	693
Number of firms			118		118		114		114	116
Adjusted R^2		0.120	0.033	0.116	0.030	0.103	0.031	0.101	0.029	0.027

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

IT measures: A max [investment in IT /employee]; B mean [investment in IT /employee]; C max [investment in IT /total investments]; D mean [investment in IT /total investment

of a fixed-effect estimator.

However, the conclusions drawn are likely to be sample-specific. The data are detailed but the sample of firms is arguably not representative enough. The main weakness, however, is that both organizational change and investments in IT are treated as exogenous, while in fact they are likely to be endogenous, through firm choice. To model these strategic choices, more and better data is needed. In spite of its limitations, the results are interesting, but further research is needed to fully understand the mechanisms at work here. The result that the different measures of IT intensity, even though capturing different types of firms, give similar effects on produdctivity growth, raises further questions: What type of organizational changes and what type of IT investments are the important ones? Are the effects equally important across indiutries? Which are the key competences among employees needed to realize the full potential?

To conclude, the employer.employee matching of Swedish registry data give uniqe opportunities to study changes to the structure of firms. In a current project, building on the results from the above analysis, changes in firm hierarchies are tied to the actual changes of different types of workers in the firm (number of managers, proffessionals etc.). This enables much more detailed information on the organizational change and its interaction with business process innovations and investments in IT.

A final remark: There has been a strong focus in the literature on the flattening of the firm's hierarchical structure. Some preliminary breakdowns on the newly collected organizational data are intriguing.[18] On the same question how number of staffing and manning levels have changed as used in this study, the share of firms indicating increases in the number of levels has doubled, compared to earlier surveys. That begs the question if the implementation of communication technology is making the pendulum turn?

[18] In the fall of 2006 Statistics Sweden together with the Riksbank collected new data on IT and indicators of organizational change identical to those used here. This data is a representative sample of 2015 Swedish firms covering the entire private sector.

Appendix A Data

Appendix A.1 Sources of data and matching

Organizational data: Plan Survey

Swedish data on re-organization and productivity is (uniquely) available through the Plan Survey, administered by the Confederation of Swedish Enterprises and the Research Institute of Industrial Economics. The Plan survey is a rotating panel survey covering mostly large firms or, more correctly, large workplaces in the Swedish manufacturing sector, and from the year 2000 onwards, also firms within the service sector. The survey is not representative, instead the aim has been to cover as much as possible of the Swedish business sector with a limited amount of observations, thus more than 90 percent of the firms covered have at least 100 employees. The purpose of this survey was originally to collect data for business cycle prognoses. Over the years the survey has developed to cover more structural issues. On two separate occasions, 1995 and 2003 questions were asked whether the firms had reorganized. In addition, in the year 2003 the survey covered indirect organizational changes; the companies were asked to state whether, for a majority of their employees, the number of tasks and/or the amount of responsibility had increased, decreased or remained unchanged. The survey is also rich on information on economic performance and labor force composition. The wave used for the study was sent spring of 2003. It covered approximately 500 workplaces in Swedish private sector, of which about 40% completed the survey.

Matching economic data from Statistics Sweden

The Plan Survey data is matched with economic register data for the years 1997-2005 to create a panel. The matching required the permission of each firm. Formal requests were sent out during spring of 2007, followed by E-mail reminders. Finally, remaining firms were contacted by phone. Out of the 192 firms, 75% gave permission to match data, 5% had changed structure to the extent that they were not meaningful to track, Only 5 firms, or 2.5% denied the request to match data. The remaining firms could, in spite of large effort, not be reached. Out of the 144 firms who gave permission we were able to successfully match 136. The estimation sample is further reduced to 120 companies due to restrictions in data as some firms lacked information on investments in IT.

Information from two different databases were matched onto the Plan Survey data. LISA is a longitudinal database compiled by Statistics Sweden. It covers every Swedish resident over 15 years of age over the years 1990 and onwards. The database contains data on education, income and employment which for the purpose of this study is aggregated to firm level. Employees are divided into four groups according to level of education; high school or less, upper secondary school, less than three years tertiary education, three or more years of tertiary education (including post graduate studies). Each category is the subdivided into field of study, age and share of immigrants. We also have information on total wage cost, for each of the major categories, i.e. wage costs for different levels of education within each firm.

From the Structural Business Statistics information on value added, gross and net investments in buildings and machinery and equipment and other detailed accounting information is matched. The Structural Business Statistics is used in the Swedish National accounts. The database covers all Swedish firms, except the financial sector. The basis for the data collection is tax declarations (SRU-material) from the Swedish tax authorities. In addition, three surveys are conducted to get detailed information on income, costs investments and assets.

Appendix A.2 Definitions and computation of variables

Organizational Change, ΔO

ΔO is represented by a dummy variable which takes the value 1 if a company reported at least two organizational changes (regardless of direction) and 0 otherwise.[19] This is true

[19] In the empirical analysis experiments are also done with restricting the ΔO dummy to be one only if firms reported at least two organizational changes in direction flatter. This does not change any of the result notably.

in 55 cases. As it turns out , the vast majority (69%) of the these are indeed in a direction flatter. 27% had mixed indicators and only 4% had purely changes that indicate an increase in hierarchy.

Capital Stocks

Capital stocks are calculated according to the Perpetual Inventory Method. Unfortunately, for this period there is no separate series for investments in IT in the Structural Business Statistics. For each firm and year there is data on net investments for only two types of capital: machinery and equipment (including IT) and structures. Capital stocks are computed for the two types of capital according to:

$$K_t^M = (1 - \overline{\delta}^M)K_{t-1}^M + I_{t-1}^M$$

where K_t^M is the real capital stock of type M at the beginning of period t, $\overline{\delta}$ is the time average depreciation rate at two digit industry level and I_t is the real net investment (gross investment minus sales) in capital M.

Capital rent prices

Capital rent price are calculated separately for the two types of capital according to:

$$P_{K^M,t} = P_{I^M,t-1}(1 + r - (1 - \overline{\delta}_M)\frac{P_{I^M,t-1}}{P_{I^M,t-2}})$$

where P_{I^M} is investment price index and $\overline{\delta}_M$ is the time averaged depreciation rate at two digit industry level.[20]

Labor composition

The panel has very detailed data on labor composition. First, the employees are divided into four different categories depending on level of education: L_1Low skilled labor, have nine years of compulsory school, L_2, Intermediate skilled labor, that have attained secondary school. High skilled labor are subdivided into two groups: L_3, with less than three years of tertiary education and finally L_4 labor with at least three years of tertiary education or post graduate education. All four levels are used in the TFP calculations, but when level of education also is controlled for in regressions only three levels are used to save on parameters, i.e. ls (low skilled), is (intermediate skilled) and hs (high skilled), where the last group is the sum of L_3 and L_4.

Within each educational level the employees are further divided according their field of study: $fos1$ is the share of employees who have a technical or engineering education, $fos2$ is the share of employees with an education in the field of economics, business administration or law, $fos3$ is the share of employees with "other" education. Finally, within each educational level there is also information on the mean age ($age1$: share 16-29 year old, $age2$: share 30-49 years old and $age3$: share over 50 years old) , gender composition (fem), and share of immigrants (imm).

ΔTFP

Following Gunnarson, Mellander and Savvidou (2004), TFP is computed as the ratio of deflated value added to and index of inputs X_k by means of a Törnquist index.

$$TFP_t = \frac{Q_t}{f(X_{1,t}, X_{2,t}, ..., X_k, t)}$$

The Törnquist index corresponds to the translog production function and allows for complementarity, for instance between organizational changes and IT. TFP growth is then computed as the difference in natural logarithm of TFP according to:

[20] Both Investment price indeices and depreciation rates are collected from Statistics Sweden national accounts.

$$\Delta \ln TFP = \Delta \ln Q - \Delta \ln X_t$$

where $\Delta \ln X_t$ is the change in inputs calculated as a weighted sum using average cost shares as weights.

$$\Delta \ln X_t = \sum_k \overline{\omega}_{k,t} \Delta \ln X_{k,t}$$

P_k are prices, and $\overline{\omega}_{i,t}$ is defined as average cost shares according to

$$\overline{\omega}_{k,t} = \frac{1}{2}\left(\frac{P_{k,t-1}X_{k,t-1}}{\sum_k P_{k,t-1}X_{k,t-1}} + \frac{P_{k,t}X_{k,t}}{\sum_k P_{k,t}X_{k,t}} \right)$$

The total factor productivity growth is calculated according to equation (**??**) using six inputs. Two types of capital: machinery & equipment and structures and four types of labor according to level of education:

Table 8: Inputs used in tfp calulations

input	description
K^S	Structures
$K^{M\&E}$	Machinery & equipment (including IT)
L_1	Low skilled labor - 9 years compulsory school
L_2	Intermediate skilled labor - upper secondary school
L_3	High skilled labor - less than 3 years of tertiary education
L_4	High skilled labor - at least 3 years tertiary education / post graduate education

Note that due to data limitations IT is included in the stock for machinery and equipment capital.

Technology, IT

There is no information on investments in IT within the Structural Business Statistics. Hence it is not possible to follow the evolution of the stock of IT capital.[21] However there is information on investments in IT within the Plan Survey for the years 2001-2003. Using this data, four different measures of the magnitude of IT investment, made *in connection* with the organizational changes, is constructed.[22] The first measure (A) categorized firms into three different groups, *zero IT*, *low IT* and *high IT,* depending on their level of maximum investment in IT per employee in the period. The *zero IT* firms reported zero investments in IT per employee for the period where organizational changes took place. *Low* (*High*) *IT* firms reported below (above) median investment in IT per employee.[23] The division divides both the sample as a whole and the sub sample that carried through organizational changes into groups of fairly equal size. Next, instead of using the maximum investment, the average investment in IT per employee is considered (B). This will decrease the impact of any one time large investment. Instead of looking at IT investments per employee it is natural to consider the mix of investments. In measure C (D) the maximum (mean) share of IT investments to total investments is considered. In C and D, instead of having zero investment as a group, the cutoffs is set at the 33th and 67th percentile to get equal group sizes. Note that the same

[21] Statistics Sweden used to cover investments in IT, but the series was discontinued in 1995. They have now decided to resume this data collection. The first survey went out in fall 2006.

[22] Depreciation of IT investments is set to 0.24.

[23] The cutoff value was set to the median of the firms that reported non zero investment levels in IT.

variable names will be used for all four measures in the estimations, which measure of IT that is used is indicated by the letters A,B,C and D in the results.

Investments

The total investment in machinery and equipment per employee, $invM\&E$, is added as a control variable. Although this means that IT investments in some sense is double counted (as IT investments only are available for three years) it captures if large in is what drives the results.

Market shares

Changes in market shares is computed using 3-digit industry level data on value added from Statistics Sweden. Changes over three different periods is considered, changes 2000-2001, changes 1999-2001 and changes 1998-2000.

Appendix B Probit estimations

In this section I try to address the fact that both the choice of reorganizing and investing in IT is likely endogenous. Equation 4 shows the result of probit estimation of equation (4). As the number of observations is so few, only industry dummy indicating service sector or manufacturing and number of employees are included as controls.

Table 9: Results: Estimating the probability of reorganization

Dependent variable: ΔO		(1)	(2)	(3)
	change measured:	1998-2000	1999-2001	2000-2001
κ_1	F	0.399	0.516	0.415
		(0.400)	(0.412)	(0.411)
κ_2	$\Delta share$	−0.033	−0.091	−0.192
		(0.074)	(0.068)	(0.143)
κ_3	Δhs	−0.072	0.051	0.127
		(0.065)	(0.061)	(0.099)
	dummy service	0.145	0.424	0.243
		(0.364)	(0.364)	(0.360)
	c	−0.817	−0.632	−0.296
		(0.662)	(0.546)	(0.543)
	Number of obs	99	96	97
	LR chi	4.2	5.2	7.37
	Prob > ch2	0.8173	0.736	0.4976
	Pseudo R2	0.0323	0.039	0.0548

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

The indicators for foreign dependence change market share have is as expected and of similar magnitude as in Crespi et al, however it is insignificant. Also changes in share of high skilled take the expected sign, albeit insignificant. The choice of long vs. short lag in changes does not seem to affect much, If anything results are somewhat stronger in the near history. The small sample makes inference hard or alternatively other factors are at play. The problem of possible endogeneity is therefore still an open question to this analysis.

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Website: www.riksbank.se
Telephone: +46 8 787 00 00, Fax: +46 8 21 05 31
E-mail: registratorn@riksbank.se

ISSN 1402-9103 E-Print, Stockholm 2009