From Boom to Burst: A Dynamic Analysis of IT Services*

Florin Maican†

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Abstract

This paper proposes a dynamic structural model to evaluate competition and to estimate changes in investment costs in the IT services. The parameters of the structural model are used to evaluate the impact of the 2001 IT bubble burst on cost structures for firms in different size classes. The empirical application builds on an eight year panel data-set including every IT service firm in Sweden, which is representative to many other European countries. The results indicate that the IT burst had a different impact on the labor and investment costs depending on firms' productivity and size class, as well as market conditions. The costs of labor increased relatively more for small and medium firms than for large firms. I find higher investments costs for operational services and maintenance and lower for software after 2000. Differences in costs across firms have potentially important implications for regulatory policy and governmental agencies that support this industry.

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†Box 640, SE 405 30, Göteborg, Sweden, phone +46-31-786 4866, Fax: +46-31-786 4154, *E-mail*: florin.maican@handels.gu.se

1 Introduction

■ The IT industry has major contributions in increasing productivity and improving service quality in virtually all sectors of economy. EU policies concentrate on encouraging the demand for IT. Increasing demand will shift investment and growth in the IT sector. Europe is still under-performing compared to North America and Asia. However, IT markets confirm strong recovery from the 2001-2003 slowdown until 2008.[1] The IT services, including software, industry has the highest growth contribution to the total IT growth (see Figure 4). EU market growth in this sector is principally driven by computer services: the EU IT market growth by segment in 2006 was as follows: computer hardware 1.8%, telecommunications equipment 2.2%, carrier services 3.5%, software 5.9%, and IT services 5.6%. One reason for the importance of IT services is that suppliers benefit (consumers get lower prices and higher quality) as companies and organization modernize their IT infrastructure. The security of IT systems remains an important sector segment.

The main aim of the paper is to quantify the costs in the IT services industry which are important for regulatory policies and governmental agencies that support this industry. Particularly, the paper uses a dynamic structural model to estimate productivity, and the investment costs in both labor and capital, capturing how firms respond to different incentives to hire/fire or to invest. In addition to quantifying costs, I measure the impact of the 2001 IT bubble burst on the costs structure of different size classes of firms. The costs analysis of the IT services industry, where sunk costs of investment might be important determinants of market structure, is required for the success of the governmental agencies programs. Shifts in the costs of entry, labor, and investment can lead to markets with fewer firms and low quality of services in the IT services industry.

The IT services, analyzed in this paper, have two features that are important for this type of analysis. First, the IT services firms are clustered around larger cities characterized by a dynamic labor market. Second, there are some sources of exogenous variation in firms incentives to invest in labor and capital. Some IT specific services grow faster in some regions than in others. In addition, firms have different sizes (small, medium,

[1] While Western European IT market was expected to grow at an annual average rate of 6.1% until 2008, the Central and East European markets are expected to grow by 13% (EU ICT Task Force Report (2006)).

large) and their expected profits from changes in labor and investment may differ systematically. IT services are considered sophisticated because the product is often highly user-specific and non-standardized. Furthermore, the services produced include more than one type of activity and the consumer is extremely important. IT services firms may want to improve their services to avoid competition or to react to changes in demand. On the other hand, a change in IT services labor may be costly if firms have to invest in redesign or to change their service practices to new customers. The direct costs of hiring a new employee are likely to be smaller than the costs involved in direct work with a new environment i.e. there is an unobserved cost when the firms hire a new employee.

The theoretical framework proposed is based on the Markov perfect equilibrium (MPE) framework of Ericson and Pakes (1995). Ericson and Pakes' framework assumes that firms make competitive investments that increase their productivity. In IT services, the type of services and their quality are important aspects and they depend on location. Because prices or other more detailed data on the IT services are not available, an accurate estimation of the quality of firm services can not be obtained from a demand model. Instead, I estimate firm productivity and assume that there exists a direct link between productivity and quality. In other words, I assume that a high productive firm also offers high services quality. I estimate firm productivity using an extension of Olley and Pakes (1996)' framework that allows for lumpy investment. Since labor is a key factor for services quality in IT industry, I back out productivity from labor demand (Doraszelski and Jaumandreu, 2007 and Maican, 2008). In addition, I assume that the all relevant features of the IT industry can be encounted into a state vector that includes firms' perceived levels of productivity and local market demographics. The states received by firms depend on the payoffs in the product market. The evolution of the state vector is influenced by entry, exit, and investment decisions. Firms' actions are subject to idiosyncratic shocks that are treated as private information. Firms choose strategies that maximize their discounted profits, given the expected strategies of their rivals. The strategy for understanding the dynamics of the IT services and for evaluating the effects of the IT bubble burst in 2001 on different size classes in this industry, proceeds in three distinct steps. First, the paper proposes a dynamic structural model of the IT services industry, where firms make optimal decisions over entry, exit, and investment given strategies of their competitors. Second, using a panel data covering 1996-2002 of the Swedish IT services industry, I estimate productivity, recover revenues and optimal policy functions consistent with the underlying model. The Swedish IT service market, that consists mainly of small firms, is representative to the majority of IT markets in EU. Two-step procedure proposed by Bajari, Benkard, and Levin (2007), which covers also continuous choices as investment, is used to recover the costs structure. Ryan (2006), Beresteanu and Ellickson (2006), Ryan and Tucker (2006), and Sweeting (2007) implement Bajari, Benkard, and Levin (2007) in a similar context.[2] Third, I use the theoretical model to simulate market outcomes with the costs structure recovered before and after the IT bubble burst. I identify the changes in the costs structure that were due to the IT bubble burst. [3] The findings give information about the cost differences across size groups of IT services firms that can be used e.g. when subsidies are allocated for different groups of firms in this industry.

In Sweden, IT services are concentrated to the largest cities Stockholm, Göteborg, and Malmö. The Swedish government focuses on the IT sector giving an important attention to firm entry and exit. The Swedish Agency for Economic and Regional Growth (NUTEK) contributes to the creation of new enterprises, more growing enterprises and more strong regions - and consequently to promote sustainable economic growth and prosperity throughout the country. The Agency requires to asses the costs and benefits of programs implemented in one industry.[4] Lundmark(1995) studies the patterns of growth and location of computer services in Sweden. More specific, he analyzes location patterns of IT services in local regional markets. He emphasizes that the market structure of the Swedish IT services is characterized by a large degree of local and regional sales, indicating the importance of proximity to customers. Most of the firms in the Swedish IT sector are small. Around 90% of the firms in my data have less than 20

[2]Pakes, Berry, and Ostrovsky (2007), Aguirregabiria and Mira (2007), and Pesendorfer and Schmidt-Dengler (2003) develop alternative extensions to the Hotz and Miller (1993)' approach to estimate dynamic games where actions have a discrete choice structure.

[3]By comparing the predictions of the model under the different cost structures, I am able to calculate the changes to a number of relevant policy measures, such as firm profits and consumer surplus, that were affected. More detailed discussion about the counterfactual analysis will present in the future version of the paper.

[4]Another Swedish government agency for innovation, Vinnova, elaborates strategies and form reference groups with key actors from the industry, government agencies and universities to improve the competitiveness in the IT industry.

employees in 2000. Moreover, only about 25% of total employment and 25% of sales are generated by these small firms in 2000. Therefore, larger firms that operate on both national and international markets are important for the overall performance of the sector.

The paper makes several contributions. First, I recover the entire costs structure of the IT services industry in Sweden including the sunk costs of entry, exit, labor and investment costs. Second, by recovering costs structure, I am able to measure the effect of the IT bubble burst in 2001 on different firm sizes in the presence of industry dynamics and market power.[5] Third, the estimated parameters will be used to conduct policy experiments evaluating how firms respond to hypothetical changes in the economic environment.

The results indicate that the 2001 IT burst had a significant different impact on the investment and labor costs and this impact depends on the firm productivity and firm's size. My findings suggest that fixed and variable adjustment costs are important determinants of investment behavior in the Swedish IT services industry. When there are sunk costs, the static evaluation ignores important economic penalties associated with the IT bubble burst costs. The findings indicate a decrease in investment costs and an increase in labor costs after the bubble burst. Interestingly, the costs of labor increase relatively more for small and medium firms than for large firms. The cost levels in different firm classes have potentially important implications for regulatory policy and governmental agencies that support this industry. Furthermore, there are higher investment costs for operational services and maintenance and lower for software after 2000. The costs with labor increase for all three IT sectors; the highest increase appears for operational services. In addition, while firms activating in software and operational services have higher scrap values (sales-off) after 2000, the maintenance and repair firms have lower scrap values. Furthermore, the results show the importance of sunk costs of entry for the market structure and it's evolution over time.

The paper is organized as follows. A brief overview of the Swedish IT services industry and relevant events over the last 10 years is given in Section 2. In addition, the

[5] Ryan (2006) evaluates the welfare costs of the 1990 Amendaments to the Clean Air Act on the US Portland cement industry using a dynamic model of oligopoly in the tradition of Ericson and Pakes (1995). Benkard (2004) examines the wide-body aircraft industry but he does not recover estimates of fixed costs.

data sources are also discussed in Section 2. Section 3 presents the theoretical model and Section 4 discusses the estimation details and presents the empirical strategy of the paper. The empirical results are presented in Section 5 whereas Section 6 discusses possible extensions.

2 Overview of the Swedish IT Services Industry

■ **The Industry.** The Swedish IT industry is in better shape than it has been for many years. IT stocks had 52% 12-month growth at the start of 2006. The Swedish IT industry had 48 firms among Europe's 500 fastest growers in Deloitte's Technology European Fast 500 in this period. However, in contrast to the IT boom of late 1990s, profits growth continues to raise due to better business models and high demand.

According to the Swedish Business Statistics 1999, the Swedish industrial classification the group 72 consist of 19.045 enterprises with around 71.000 employees. The total net turnover was SEK 97 billion and value added was SEK 43.8 billion. It is important to note that large firms have many subsidiaries in the same sector. Software consultancy is the sub-sector with the largest share of firms, employees, turnover and value added in relation to the total value for each of these variables. Moreover, IT service firms are also found in the following sectors: retail trade in computers, office trade and software; wholesale trade in office machinery and equipment; and wholesale trade in telecom products and electronic components. It is hard to specify what kind of activity those firms have. Therefore, those firms are excluded as incumbents, but they are included as potential entrants.[6] The Swedish IT services industry is dominated by large companies, with more than 250 employees. They represent 0.2% of the total number of companies and their net turnover represents 41% of the total net turnover in the industry.

□ **Market definition.** The paper uses the Statistics Sweden's county definition as my market definition. Counties consist of a collections of municipalities. This classification groups the municipalities(290) into 25 markets that are mutually exclusive and exhaustive of the land mass of the Sweden.[7] The county-based market definition

[6]However, the share of total turnover in these sectors that represents IT consultancy activities cannot be determined from the survey or from Swedish Business Statistics in 1999.

[7]See Statistics Sweden for more detailed information, www.scb.se.

is a compromise between contradictory requirements. The theoretical model assumes that IT service markets are isolated geographic units; firms in one market competitively interact only with other firms in the same county market. Firms placed in too large markets may not all respond to the same market forces (external or actions of industry competitors). Counties are a suitable compromise to resolve the tension between isolating markets yet ensuring that the IT service firms within them are interconnected. IT service firms should be, however, close to their customers. Large firms in this sector may have international competitors if they sell, for example software.

SCB conducted a survey about demand structure in the Swedish IT services industry in 2001. They found that the customers for Swedish IT services are as follows: firms and public utilities around 76%; central government and municipal authorities - 14%; households and individuals - 0.2%; and exports around 10%. In the survey were included only firms that are in the SE-SIC 92 group 72. The customers of small firms are households and private individuals. Large and medium IT firms have business enterprises as customers. While, large companies dominate the Swedish IT services in terms of market share, small and medium companies dominate the market as number. Firms that are in other SE-SIC 92 groups and provide IT services are not encounted in the survey due to the difficulties in measure their activities.[8] Moreover, 50% of firms say that 75-100 per cent of their sales come from neighbor municipalities and 35% firms do not sales in neighbor municipalities.

My data provide demographic information of individual counties. The demographic characteristics of the counties, such as population, number of firms other than IT service firms are a good proxy for demand.

□ **Data.** This paper draws on a census of Swedish IT services industry, provided by Statistics Sweden, Financial Statistics(FS) and Regional Labor Statistics (RAMS). The Swedish industrial classification code (SE-SIC 92) for this industry is 72. While RAMS contains information on employee education and wages, FS contains information about firm input and output. The data set covers from 1996 to 2002. A unit of observation is firm. Appendix A provides additional information about the data and variable definitions.

[8]For more details see Cerda and Glanzelius (2003).

The IT services industry includes the following subgroups: hardware consultancy; software consultancy - customized software and packages software; data processing; database activities; maintenance and repair of office, accounting and computing machinery and data processing equipment. It is difficult to divide IT consultancy services for hardware and software. On the other hand, data processing, database activities and other computer related services can be grouped into operational service activities. This is the reason for having both subgroups in the data. Major changes affected the computer consultancy sector during last years. New firms have appeared while others have exited or merged.

Information is what is demanded in the IT services industry. How much will be demanded and who will demand depend on the type of activity carried on in Sweden, price, training effort, and the level of learning.[9] I group the firms in three classes after the number of employees: (i) small - 0-19 employees; (ii) medium - 20-99 employees; and (iii) large - over 100 employees.

3 The modeling approach

■ **The model.** To evaluate the IT burst impact on the cost structure it is necessary to have a theoretical model that captures the important aspects of the IT services industry. The IT industry is characterized by simultaneous entry, exit, investment and production service decisions of firms in each local market. The structure within each county market is primarily determined by the distribution of capacities (IT labor) and the industrial structure of market. The model is build on the work of Ericson and Pakes(1995), who provide a theoretical framework of industry dynamics.

The principal idea of the model is that all economically important characteristics of firms are en-counted into a state vector. Firms receive state-dependent revenues from the product (service) market in each period. Entry, exit, and investments (labor and technology) influence the evolution of the state vector. Equilibrium is obtained when firms follow strategies that maximize the expected discounted present value of their stream revenues given the expected strategies of their competitors.

[9] See Bower (1973) for more details.

This paper adapts a general framework to account for specific features of the IT services industry. The IT industry is characterized by heterogeneous firms, where skilled labor, demand, and the efficiency of using new technologies are the most important aspects. In each period, incumbents compete over service quantities, subject to a private shock that shifts the firms' marginal cost. Each incumbent makes optimal decisions whether to continue or to exit. If firm decides to exit the market it receives revenues from both the service market and a final scrap value before disappearing. There is a pool of short-lived potential entrants who must decide whether or not to enter, paying a privately-known sunk cost of entry if they enter. Investments in knowledge and technology change the quality of IT services tomorrow with firms paying both fixed and variable adjustment costs. The paper assumes that firm strategies depend only on the current state vector and generate a Markov - Perfect Nash Equilibrium (MPNE). The MPNE consists of a set of best response strategies governing entry, service production, exit, and investment. The study describes each component of the model in detail in the following sections by deriving the ex-ante value functions for potential entrants and incumbents. These value functions are important in the counterfactual simulations when I evaluate the welfare costs of the IT bubble burst.

□ **State Space.** The state space is composed of (i) a set of firms, set of markets, and a set of characteristics (firm and market) that are observed by all firms, (ii) a set of private information payoff "shocks" that affect firm's payoff. The number of firms in the market m is denoted by N_m. The most important component of the state space is productivity ω. Firm's productivity ω is not directly observable in the data, but it is backed out through estimation of a production function model. I assume that firm's productivity and market demographics evolve according to stochastic processes. In this case, the productivity represents the experience, skills of firm employees, and management of firm. The paper assumes that the productivity evolves stochastically according to the following process:

$$(1) \quad \omega_{jmt} = \tilde{g}(\omega_{jmt-1}) + \upsilon_{jmt},$$

where $\upsilon_{jmt} \in N(0, \eta^{\omega})$ and $\tilde{g}(\cdot)$ is an unknown function. Thus firm's actual productivity ω_{jt} in period t can be decomposed into expected productivity $\tilde{g}(\omega_{jt-1})$ and a random shock υ_{jt}. The shock υ_{jt} may be thought of as the realization of uncertainties that are naturally linked to productivity. The conditional expectation function $\tilde{g}(\cdot)$ is unobserved by the econometrician (though known to the firm) but it and can be estimated non-parametrically. Furthermore, I assume that ω_{imt} evolves independently across markets.

☐ **Market Characteristics.** Each market m is defined by its characteristics: the total number of firms (other than IT) in the market and population. Another assumption is that the growth rates for population and number of non-IT firms evolve according to the following AR(1) process

$$(2) \quad pop_{mt} = \delta_1^{pop} pop_{mt-1} + \delta_0^{pop} + \upsilon_{mt}^{pop}, \text{where} \quad \upsilon_{mt}^{pop} \sim N(0, \eta^{pop})$$

and

$$(3) \quad firms_{mt} = \delta_1^{firms} firms_{mt-1} + \delta_0^{firms} + \upsilon_{mt}^{firms}, \text{where} \quad \upsilon_{mt}^{firms} \sim N(0, \eta^{firms})$$

☐ **Timing.** There are an infinite sequence of years. In each year the timing of the game is as follows:

1. each firm observes its current firm productivity and market demographics.
2. each potential entrant receives a draw from the distribution of entry values and make its entry decision; each incumbent firm makes its investment decision.
3. each firm receives a private productivity shock and then they compete in the product market.
4. each incumbent that chooses to leave the market exit and receive its scrap payment; each entrant pays their entry fee.
5. the state vector adjusts as investment mature and firms enter and exit.

A firm makes investment decisions in labor and capital investment without knowing the decisions of their competitors. Firm observes the state variable at the beginning of each period along with the entry, exit, investment, and production decisions of its rivals in the previous period. Private information shocks are drawn independently across periods from a known distribution. It is important to note that, firms do not update their expectations of the future behavior after observing the actions of their rivals.

■ **Equilibrium Concept.** Firm j makes decisions, such as entry, exit, and investment decisions collectively denoted by Γ_j. Because the full set of dynamic Nash equilibria is unbounded, I restrict firm's strategies to be anonymous, symmetric, and Markovian. Therefore, a firm's strategy, σ_{jt}, can be written as a mapping from states to actions:

$$\sigma_{jt} : S_{jt} \rightarrow \Gamma_{jt}.$$

A vector of strategies is a mapping of the current state of the system for each firm's strategy. The time horizon is infinite, payoffs are bounded, firms have Markovian strategies, and the discount factor β is positive and less than one. The value of a firm in state $s \in S$ is

$$(4) \quad V_j(s|\sigma(s)) = \pi_j(\sigma(s)) + \beta \int V_j(s'|\sigma) dP(s'|\sigma(s), s),$$

where $\sigma(s)$ is the vector of strategies, $\pi_j(\sigma(s))$ is the per-period payoff function, and $P(\cdot)$ is the conditional probability distribution governing the transition between states. A strategy profile σ is a Markov perfect equilibrium giving competitors profile σ_{-j} if each firm j prefers strategy σ_j to all Markov strategies $\sigma_j^{'}$

$$(5) \quad V_j(s|\sigma_j^*, \sigma_{-j}) \geq V_j(s|\sigma_j^{'}, \sigma_{-j})$$

for all j, s, and $\sigma_j^{'}$. I assume that such an equilibrium exists and it is unique (see Doraszelski and Satterhwaite, 2003) for details on existence and uniqueness).

4 Estimation

The estimation takes place in two steps. In the first step, I estimate production function, which allows me to recover an estimate of each firm's perceived productivity. Knowing how the state space evolve over time, I can estimate the revenue generating function and the policy functions that describe the optimal strategy profile for each firm. In the second step, the dynamic parameters governing investment, scrap values, and sunk costs are recovered.

□ **Firm productivity.** The papers assumes a Cobb-Douglas technology where IT service firms sell a homogeneous product and that the factors underlying profitability differences among firms are neutral efficiency differences. By allowing for heterogeneity in the dynamic model, it makes this assumption not so restrictive. The production function can be specified as

$$(6) \quad q_{jt} = \beta_0 + \beta_l l_{jt} + \beta_k k_{jt} + \omega_{jt} + \xi_{jt}$$

where q_{jt} is the log of service output sold by firm j at time t; l_{jt} is log of labor input; and k_{jt} is log of capital input. The unobserved ω_{jt} is productivity, and ξ_{jt} is either measurement error (which can be serially correlated) or a shock to productivity which is not predictable during the period in which labor can be adjusted.

Since specification (6) assumes prices are constant across firms, when firms have some market power, prices set by individual firms influence their productivity. By cutting the price, more inputs are needed to satisfy increasing demand. This negative correlation between input and prices leads to underestimation of the labor and capital parameters in the production function (Klette and Griliches, 1996; Melitz, 2000; and De Loecker, 2006). If the products are perfect substitutes, deflated sales are a perfect proxy for unobserved quality adjusted output. Following this literature, it is possible to correct for bias in elasticities by introducing the following downward sloping demand function

$$(7) \quad p_{jt} = p_{It} + \frac{1}{\eta} q_{jt} - \frac{1}{\eta} q_{It} - \frac{1}{\eta} u^d_{jt}$$

where p_{jt} is output price, while p_{It} and q_{It} are IT service output price and quantity. An additional assumption is that firms operate in a market with horizontal product differentiation, where η (< -1 and finite) captures the elasticity of substitution among IT services. Because of data constraints the demand system is quite restrictive, implying a single elasticity of substitution for all IT services, there are no differences in cross price elasticities. Therefore, a more sophisticated demand model that allows for product differentiation is not possible to use (Berry 1994; Berry, Levinsohn, and Pakes, 1995; Nevo, 2001). Since the IT service prices of individual firms are unobserved, I deflate output with the industry price deflator; Deflated output is defined as $y_{it} = q_{it} - p_{It}$. Since firm productivity follows a first order Markov process, it takes the following form $\omega_{jt} = \tilde{g}(\omega_{jt-1}) + \upsilon_{jt}$. Controlling for price and demand shocks in the production function in (6), the production function becomes

$$(8) \quad y_{jt} = \left(1 + \frac{1}{\eta}\right)[\beta_0 + \beta_l l_{jt} + \beta_k k_{jt}] + \left(-\frac{1}{\eta}\right) q_{It} + g(\omega_{jt-1}) + \varepsilon_{jt} + \zeta_{it}$$

where $g(\cdot) = \left(1 + \frac{1}{\eta}\right)\tilde{g}(\cdot)$ and $\varepsilon_{jt} = \left(1 + \frac{1}{\eta}\right)\upsilon_{jt}$. The value of k_{jt} is determined by previous investment i_{jt-1}. Labor l_{jt} is correlated with the random shock in productivity ε_{jt}. The inverse labor demand helps us to recover unobserved productivity ω_{jt-1} rather than recovering from OP and Ackerberg, Caves, and Fraser (2005) (ACF) using the unknown policy function of investment in capital and labor/ materials (Doraszelski and Jaumandreu, 2007). The main advantage is that zero investments are included in the analysis, which is important because IT firms often invest one year, followed by several years without investment. In year t-1, firms chose current labor l_{jt-1} based on current productivity ω_{jt-1}, which gives demand for labor as

$$l_{jt-1} = \frac{1}{1-\beta_l}[\beta_0 + ln(\beta_l) + \beta_k k_{jt-1} + \omega_{jt-1} - (s_{jt-1} - p_{jt-1}) + ln(1 + \frac{1}{\eta})]$$

where w_{jt-1} is total wages paid. Solving for ω_{jt-1} yields

$$(9) \quad \begin{aligned} \omega_{jt-1} = \; & \tfrac{\eta}{1+\eta}\Big[\lambda_0 + [(1-\beta_l) - \tfrac{1}{\eta}\beta_l]l_{jt-1} + w_{jt-1} - p_{It-1} - \left(1+\tfrac{1}{\eta}\right)\beta_k k_{jt-1} \\ & + \left(\tfrac{1}{\eta}\right) q_{mt-1} + \left(\tfrac{1}{\eta}\right) u^d_{jt} - \epsilon_{jt}\Big] \end{aligned}$$

where $\lambda_0 = -ln(\beta_l) - ln(1+1/\eta) - \beta_0(1+1/\eta)$ combines the constant terms $-\beta_0$, $-\beta_l$, and η.[10]

Since there is a large turnover in the industry, it is important to control for selec-

[10]The condition for identification is that the variables in the parametric part of the model are not perfectly predictable (in the least square sense) by the variables in the non-parametric part (Robinson, 1988). Hence, there cannot be a functional relationship between the variables in the parametric and non-parametric part (see Newey, Powell, and Vella, 1999). Including additional variables that affect productivity guarantee the identification.

tion. The OP approach to control for selection is to substitute the predicted survival probability into $g(\cdot)$. Thus, the final production function to be estimated is

$$(10)\quad y_{jt} = \left(1 + \frac{1}{\eta}\right)[\beta_0 + \beta_l l_{jt} + \beta_k k_{jt}] + \beta_q q_{mt} + g(\mathscr{P}_{t-1}, \omega_{jt-1}) + \varepsilon_{jt} + \zeta_{it}$$

where ω_{jt-1} comes from (9). The production function (10) is estimated using the sieve minimum distance (SMD) procedure proposed by Newey and Powell (2003) and Ai and Chen (2003) for independent and identically distributed (i.i.d) data. The goal is to obtain an estimable expression for the unknown parameters $\boldsymbol{\beta}$ and g_{K_T} where K_T indicates all parameters in $g(\cdot)$. To approximate $g(\cdot)$ a third order polynomial in ω_{t-1} is used.[11] A tensor product polynomial series of labor, capital, large entrants and local market conditions are used as instruments. To compute ω_{t-1} and, hence, to approximate $g(\cdot)$ we use the following instruments This set of instruments is also used to estimate (10) using the optimal weighting matrix are the following: $\{1, l_{t-1}, s_{t-1}, k_{t-1}, p_{It-1}, w_{mt-1}, pop_{mt-1}, firms_{mt-1}, \}$. Using the specified GMM implementation, the parameter values $(\boldsymbol{\beta}, g_{K_T})$ are jointly estimated. I use the Nelder-Mead numerical optimization method to minimize the GMM objective function.

□ **Static Firm Payoffs.** Firm's payoff in one period depends on its productivity, competitor's productivity, demand, and firm's investment decisions. Therefore, the payoff of firm j in market m, in period t is

$$(11)\quad \pi_{jmt}(s, \omega_{jmt}; \beta, \theta) = \quad r_{jmt}(x, d_\omega, \varepsilon^r_{jmt}) - c_i(i_{jmt}; \theta^i) - c_l(\Delta l_{jmt}; \theta^l),$$

where X captures both firm and local market observed characteristics; D_ω captures the local competition; $c_i(\cdot; \theta^i)$ and $c_l(\cdot; \theta^l)$ are cost functions associated with investment in technology (machinery) and knowledge (skilled labor). I assume the following revenue function $r_{jmt}(x, d_\omega, \varepsilon^r_{jmt})$ form:

$$(12)\quad r_{jmt} = \beta_{my(t)}(1 + x_{jmt}\beta^x)(1 + d_\omega \beta^\omega) + \varepsilon^r_{jmt},$$

[11]For robustness, the expand $g(\cdot)$ using a 4th order polynomial was also used, but the results were, however, similar.

where $\beta_{my(t)}$ are the set of market-year effects introduced to capture differences in other unobserved factors that are common across all firms in a market. Variables x captures characteristics such as productivity, size, as well as local demand such as population and the number of firms (other than IT services). Furthermore, I allow firm's revenues to vary with degree of competition, captured in d_ω.

□ **Entry, Exit, Labor and Investment Costs.** The per period payoff for each firm depends on the costs of its actions, which in turn depends on whether the firm is an entrant, a continuing incumbent, or an incumbent that has chosen to exit. The payoff function for the entrant is a simple function of the fixed entry cost ($sunk_j$) and their initial investment i^e and labor l^e:

$$\pi_j(s) = -sunk_j - c_i^e(i^e;\theta^i) - c_l^e(\Delta l^e;\theta^l)$$

In the empirical application, while the cost of investment function has a quadratic form, the cost of labor has a linear form. Incumbent firms obtain the payoff from the product(service) market in the current period and the scrap value if it exits the market. The payoff function for continuing incumbents is given by:

$$(13) \quad \pi_j = \tilde{r}_j - c_i^{in}(i^{in};\theta^i) - c_l^{in}(\Delta l^{in};\theta^l),$$

I assume a quadratic form for $c_i^{in}(i;\theta^i)$ and allow it to vary according to whether the investment in technology an labor are positive or negative (Ryan, 2006 and Beresteanu and Ellickson, 2006). Finally, incumbents that choose to exit have a payoff function given by

$$(14) \quad \pi_j(s) = \tilde{r}_j + scarp_j,$$

where $scarp$ is the sell-off value associated with closing down the firm and exiting the IT services market.

□ **Estimation of firm policy functions.** I use the estimated productivity to estimate firm policy functions i.e. firm's policy rules for choosing its investments or exit. A firm's policy rule assumes optimal behavior (see Hotz and Miller, 1993), therefore the policies can be computed from estimates of the probabilities of making different choices given the observed state variables.

Probability to move from one state of the system to another is given by the combinations of all paths that can lead to that state. This implies that probability of achieving a new state depends on investment, entry, and exit. For any change in the state vector, I account for entry, exit, and investment decisions of incumbents and potential entrants. The probability of entry and exit can be written in terms of the optimal entry and exit strategies:

$$(15) \quad Pr(entry|s_j) = \int \Theta(s_j, sunk_j) dG(sunk_j)$$

$$(16) \quad Pr(exit|s_j) = \Phi(s_j).$$

Both conditional probabilities can be approximated using probit models (Ryan, 2006, Beresteanu and Ellickson, 2006). The paper follows this literature and uses probit approximation.[12] To be more precise, I estimate the following entry and exit policies for all states:

$$\begin{aligned} Pr(entry|s) = \ & \phi(\alpha_0 + \alpha_1 rival\_productivity + \alpha_2 firms \\ & + \alpha_3 pop + \alpha_4 after2000) \\ Pr(exit|s) = \ & \phi(\alpha_0 + \alpha_1 productivity + \alpha_2 rival\_productivity \\ & + \alpha_3 firms + \alpha_3 pop + \alpha_4 after2000) \end{aligned}$$

Both policy functions contain a dummy variable for before and after 2001 IT bubble burst.

□ **Value Functions.** The ex-ante value functions for both potential entrants and incumbents can be written down. The value functions give the expected discounted present value, in SEK, of being at a given state vector. The value function has two components: (i) the per-period payoff function and (ii) the continuation value i.e. - expected value of next period's state. Firms use their value function to find their optimal entry, exit and investment policies.

The value function for the potential entrant j who decides to enter in the next period

[12] In many cases, entry and exit strategies take the form of simple cutoff rules in dynamic oligopoly models.

conditional on the current state and the draw from the sunk cost of entry, $sunk$, can be written as:

$$(17) \quad V_j^e(s, sunk_j) = \max_{i_j^e, l_j^e} \left\{ -sunk_j - \theta_0^i - \theta_1^i i_j^e - \theta_2^i (i_j^e)^2 - \theta_1^l \Delta l_j^e + \beta E(V(s')|s) \right\}$$

The value function for an incumbent has two parts. The first part corresponds to whether or not the firm decides to exit the industry. If the firm leaves the market it receives its services-market payoffs $\pi_j(s)$ and its scrap payment, $scrap$. If the firm remains active, it receives service market revenues. Therefore, if firm j continues it obtains the following payoff

$$(18) \quad \begin{aligned} V_j^{stay}(s) = \max\nolimits_{i_j, l_j} & -1(i_j > 0)(\theta_0^{i,+} + \theta_1^{i,+} i_j + \theta_2^{i,+}(i_j)^2) \\ -1(\Delta l_j > 0)((\theta_0^{l,+} - \theta_1^{l,+} \Delta l_j) & - 1(i_j < 0)(\theta_0^{i,-} - \theta_1^{i,-} i_j - \theta_2^{i,-}(i_j)^2) \\ & -1(\Delta l_j < 0)(\theta_0^{l,-} - \theta_1^{i,-} \Delta l_j) + \beta E(V(s')|s) \end{aligned}$$

The ex-ante value function for an incumbent is a combination of the payoffs of firms that stay and firms that exit:

$$(19) \quad V_j(s) = \int \pi_j(s_j) dS + (1 - \phi(s_j)) V_i^{stay}(s) + \phi(s_j) scrap_j$$

The value functions are important in the empirical strategy.

■ **Estimating Structural Parameters.** The law of motion of the state vector and the level of payoff associated with each state are described by the first step estimation of the productivity and policy functions. In the second step of the estimation, I recover the rest of parameters of the payoff and cost functions by finding the set of parameters that make the firm's policy function optimal. Having the estimates from the first stage, the evolution of the market under different conditions can be simulated. This is possible because the first stage estimates characterize what each firm should do in all possible situations. Using forward simulation, I find parameters of the optimal policy function that minimize the profitable deviations from these observed strategies.

I simulate the firm behavior under two alternative strategies in order to identify the investment cost parameters. The first scenario implies that all firms use the optimal strategies recovered in the first stage; this strategy is denoted by σ. The second scenario implies that a single firm deviates from the optimal strategy, but all other firms use the optimal strategies. The strategy profile σ is an MPE if and only if

$$(20)\quad V_j(s,\sigma_j,\sigma_{-j};\theta) \geq V_j(s,\sigma_j^{'},\sigma_{-j};\theta)$$

for all states s, all firms i, and alternative profiles $\sigma_j^{'}$. The minimum distance estimator is constructed using this set of inequalities. Due to the linearity in the cost functions, the optimality conditions (20) can be re-written as $[W_j(s,\sigma_j,\sigma_{-j};\theta)-W_j(s,\sigma_j^{'},\sigma_{-j};\theta)]\theta \geq 0$. The above equation can be written in terms of profitable deviations from the optimal policy

$$(21)\quad g(x;\theta,\alpha) = [W_j(s,\sigma_j,\sigma_{-j};\theta) - W_j(s,\sigma_j^{'},\sigma_{-j};\theta)]\theta,$$

where α represents the parametrization of the policy functions. More specific, alternative policies from a distribution F over all policies are drawn to generate a set of inequalities indexed by x.

The estimates of W_j, denoted $\tilde{W}_j$ are obtained using forward simulation and I use them in the sample analog of the objective function

$$(22)\quad Q_n(\theta,\alpha) = \frac{1}{n_I}\sum_{k=1}^{n_I}(min\{\tilde{g}(x,\theta,\alpha),0\})^2$$

I use the Laplace-type estimator to estimate the parameters (Ryan (2006) and Chernozhukov and Hong (2003)). In addition, I estimate the distribution of entry costs using a procedure that matches the observed entry rates to the simulated values of entering at each state.

5 Results

This section presents the results of estimates of productivity, revenues generating function, and optimal firm's policies i.e. entry, exit, investment in technology and labor. In addition, the estimated costs parameters are discussed in the second part of this section.

Before I discuss the estimated productivity results in detail, a short summary of labor productivity and capital intensity is presented. 1 and 2 present the evolution of labor productivity distribution and capital intensity for the three IT services sectors. The labor productivity is measured as value added per number of employees. The low labor productive firms (10th percentile) in software and operational services experience a decrease in labor productivity from 1999 to 2001, but they start to recover in 2002. The peak of median labor productivity for all sectors is in 1999; the median labor productivity has a negative trend after this period for software and maintenance sub-sectors. The high labor productive firms (90th percentile) increase their labor productivity during the studied period. The dispersion of labor productivity decreases in all sectors after 2000 (with larger speed in operational services). To avoid the possible outliers, I measure the productivity dispersion as the interquartile range over median. The next step is to look into capital intensity. While the median and the 90th percentile of capital intensity have an upward trend in all three sectors, the 10th percentile decreases in maintenance sector after 2000 and in operational services after 2001 (see figure 2). The capital intensity dispersion increases for maintenance and for software (small slope in trend) during the studied period. For operational services, the capital intensity dispersion decreases until 2001 when it starts to increase.

■ **Productivity Estimates.** The theoretical model assumes that productivity is the state variable that capture all the important aspects of a firm. Table 4 presents the results from estimating the production function using different estimators. By using the OLS estimator the labor elasticity is 0.95 and the capital elasticity is 0.19. The OLS estimator is affected, however, by both endogeneity and selection problems. Since firm's productivity is positively correlated with labor, the large value of labor coefficient is not a surprise. Furthermore, it is expected that firms with large capital stock (large firms) to stay in the market even if they have low productivity. By omitting to control for selection, it is expected that the coefficient of the capital to be down biased. Furthermore, the results show that the null hypothesis of constant return to scale is accepted using the OLS estimator. The next estimator used is ACF. Using ACF estimator, I control for both endogeneity and selection using the whole sample but controlling for IT sub-sectors and years. The elasticity of labor goes down to 0.93. To somewhat surprise the elasticity of the capital also goes down to 0.17. ACF estimator controls for investment in market threshold function that affects the likelihood of exit, but it does not control for prices or wages. The last two columns of the Tables 4 show the estimates of production function using the extended Olley and Pakes (1996) estimator (EOP) presented in section 4. In addition to the endogeneity and selection, the main advantage of this estimator is that it also controls to some extend for price bias by introducing a simply demand function. This allows me to present estimated mark-ups for the IT services. Since we expect to have different demand elasticities for the IT sectors, I do separate estimations for software and for operational services and maintenance. The column 3 presents the estimates for software sub-sector. The elasticity of labor goes in the right direction i.e. goes down to 0.26 and the elasticity of the capital increases to 0.45. The estimated elasticity of demand for software industry is around -13 which implies a mark-up of 1.08. The estimated labor and capital coefficients for operational services and maintenance are 0.29 and 0.43. The demand elasticity is around -3 which implies a mark-up of 1.52.[13] The productivity estimated using EOP estimator is used in the rest of the paper.

Figure 3 shows the evolution of different parts of the productivity distribution for different size classes. The figure does not make the distinction from what IT sector the firms belong. The small firms that are low productive increased their productivity over time. Medium firms that are less productive also increased their productivity over time until 2001 when the burst affects negatively their productivity. The large IT firms with low productivity experienced an increase in their productivity until 2000 from where their productivity starts to decrease. To summarize, the low productive IT firms that are the most affected are medium and large firms. Furthermore, the results indicate that the median productivity for small and medium firms increases during the studied period, the median productivity of the large firms increases until 1999 from starts to decrease until 2002. The next step is to look that the evolution of the high productive firms by their size. The large firms with high productivity decrease their productivity; The lowest value of the 90th percentile productivity for large firms is found in 2001. The same aspects are also found for medium firms; Compared to large firms, the difference is that in the case of medium firms there is a smaller dispersion in the 90th percentile productivity. Both medium and large firms with high productivity experience an in-

[13] It would be more informative if I could estimate the mark-ups before and after the IT burst. Unfortunately, this is not possible due to the data constraint.

crease in productivity from 2001 to 2002 i.e. the increase for median firms is greater than for large firms. One important aspect to look on is the evolution of dispersion in productivity for different size classes. The results indicate that productivity dispersion decreases over time with one exception: the exception is that the productivity dispersion for large firms increases from 2001 to 2002. A decrease in productivity dispersion can be interpreted as in increase in competition i.e. firms become closer to each others. Summarizing, the paper finds that 2001 IT bubble burst affects firms in different ways depending on their productivity and size. Among the large firms those with low and median productivity were affected the most by the burst. Medium IT firms were affected in different ways depending how productive they were. Regarding small firms, only small high productive firms where affected by the burst. A possible explanation might be that they are high specialized and the shocks in demand affect more their productivity.

■ **Revenues generating function.** Having the estimated productivity for each firm, I estimate the revenues generating function. The estimation of the revenues generating function is needed to evaluate the value functions. The revenues generating function is estimated separate for each size class. This study estimates the revenues as a function of firm's productivity, rivals' productivity as well as the number of competitors in different size classes. Table 5 presents the results. All the coefficients have the expected signs and they are significant. Firm's productivity has a positive effect on the revenues; the largest effect of own productivity on revenues is estimated for large firms. While rivals' productivity has a positive effect on the revenues for small firms, it has a negative effect for medium and large firms. I compute the rivals productivity as the average of other firms in the same sector and market (county). The number of small and medium IT competing firms have a negative impact on revenues, but number of large firms has a positive impact. One possible explanation is that the large firms are located in large cities where there is large demand. In addition, the revenues of medium firms are the most affected by the 2001 IT bubble burst.

■ **Policy functions.** The next step is to estimate policy functions for incumbents and potential entrants. I estimate these policy functions for each size class (small, medium, and large). The exit and entry policies are estimated by probit. The empirical results are presented in Tables 6, 7, and 8. IT firms are less likely to exit a market if the market is growing and if they have higher productivity (only for medium IT services firms). Firms are also more likely to exit if their rivals have higher productivity. Finally, the 2001 IT burst increased the likelihood of exit. The results indicate that IT firms are more likely to exit if there are many small firms in the market. On the other hand, I find that firms are less likely to exit the market if there are many medium and large firms.

The entry decisions are presented in the second columns of Tables 6, 7, and 8. I find that entry is less likely in markets with higher productivity (only for medium firms) and more small firms. Moreover, there is more entry in markets with more medium and large firms. These findings might reflect unobserved features of demand.

Finally, I consider the capital investment level and labor chosen by new entrants and by incumbents. For new entrants, I find that IT services firms choose higher levels of investment in large markets (small and medium firms), in markets characterized by higher productivity among rivals (only small firms), and in markets with a large number of medium firms. For incumbents, the results indicate that firms choose higher levels of investment in large markets (small and medium firms), in markets with higher productivity among rivals (only large firms), and in markets with a large number of medium firms. In addition, new entrants choose higher levels of labor in large markets (small and medium firms) and in markets with a large number of medium firms (small and medium firms).

I also estimate separate policy functions for each IT sector.[14] These additional results are discussed bellow. The entry is more likely to occur if the market is growing and in markets with many IT firms. On the other hand, entry is less likely to occur if the incumbents have high productivity (software and maintenance) and after 2000 (software and operational services). My findings indicate that exit is less likely if the market is growing (software and maintenance) or if the firm has large capital stock (software and operational services). In contrast, the IT services firms are more likely to exit if firm has low productivity, rivals have high productivity (software), or if they face high competition (only for software and maintenance). The factors that increase the investment are capital stock, own productivity (software), rivals' productivity (software), and

[14] The results are not reported in the current version, but they are available from the author.

demand (software). In addition, I find that rivals' productivity has a positive impact on investment for software firms. In case of software and maintenance, the results indicate lower investment after 2000 and in markets high demand. I also estimate policy function for technical labor (at least three years of technical education). The following factors have a positive impact on the number of technical employees: own productivity and large capital stock (software and operational services). The burst has a positive impact on the number of technical employees. Moreover, few technical employees are observed if rival firms have high productivity (software), if the competition is high, if own productivity is lower than the 25th percentile or above 75th percentile productivity in the local market level. Furthermore, the findings indicate that the entrants choose large number of technical employees if the incumbents have high productivity.

■ **Recovering costs parameters.** In the second step, I recover the costs parameters. First, I recover the parameters associated with the costs of investing in capital and in labor. Then I can recover the average sunk costs.[15] First, Table 9 presents my preliminary estimates the cost functions parameters for each size class. All the coefficients have the expected sign. The parameter estimates of investment costs in both capital and labor are positive and significant for all size classes. However, the estimated costs are larger than the costs evaluated from data. My findings indicate a decrease in investment costs and an increase in labor costs after the bubble burst. Interestingly, the costs of labor increase relatively more for small and medium firms than for large firms. Second, Table 10 shows the estimated costs parameters for each industry. I find higher investments costs for operational services and maintenance and lower for software after 2000. The costs with labor increase for all three IT sectors; the highest increase appears for operational services. In addition, while firms activating in software and operational services have higher scrap values (sales-off) after 2000, the maintenance and repair firms have lower scrap values. As I mention previously, since my estimates are preliminary the results have to be interpreted with care.

[15] The sunk costs of entry will be presented in a future version of the paper.

6 Policy Experiments

Having the estimated structural parameters, I can do policy experiments. In this section, I therefore intend to use those parameters for conducting policy experiments that constitute the main empirical contribution of the paper. In detail, I will use the Pakes and McGuire (2001)(PM)' algorithm to study two different experiments. In the first experiment, I allow all three size classes of firms to be on the market. In the second experiment, I allow only large firms to be on the market. Under both experiments, I simulate the behavior of the firms using the PM algorithm. These experiments allow me to see how the size distribution of firms and productivity of firms evolve over time. In addition, I can analyze how the size distribution of firms and their productivity change as I apply hypothetical changes in the economic environment. Future versions of the paper will contain a more comprehensive discussion on these issues. The size of the firms' costs have potentially important implications for regulatory policy and governmental agencies that support this industry.

7 Conclusions

The paper analyzes the competition and evaluates the 2001 IT burst impact on the cost structure in the Swedish IT services. The study finds that among the low productive IT firms the most affected by the burst were medium and large ones. The results indicate that the median productivity for small and large firms increase during the studied period; large IT firms with decrease their productivity; rival's productivity has a positive impact on the revenues of the small firms and a negative effect for medium and large IT services firms. In the software subsector I find that firms are more likely to exit if the rivals have higher productivity; rivals' productivity has a positive impact on investment; own productivity and large capital stock have a positive impact on technical labor (this is also true in operational services subsector); and rivals' productivity has a negative effect on the number of technical employees. Finally, the results show a decrease in investment costs and an increase in labor costs after the 2001 bubble burst.

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Table 1: Computer Services Industry Summary Statistics

Year	Firms	Sales	Value Added	Total Wages	Employees	Investment
1996	4,116	483,205	214,591	120,706	42,686	14,628
1997	4,581	532,099	257,076	145,065	49,883	17,754
1998	5,109	667,078	313,956	178,511	59,208	18,591
1999	5,625	833,694	382,827	227,871	71,133	27,187
2000	6,523	962,844	397,109	280,857	85,928	30,930
2001	6,749	1,129,795	485,886	323,126	94,096	27,051
2002	6,623	1,009,312	446,728	298,046	87,567	28,761

NOTE: Summary statistics for the Swedish Computer Service Industry 1996-2002. The data are from the merge between Financial Statistics(FS) and Regional Labor Statistics(RAMS) databases. Sales, value-added, wages, investment are measured in thousand 1996 SEK.

Table 2: Summary Statistics

Variable	Minimun	Mean	Median	Maximum	Standard Deviation
Demand Data					
Sales	257.33	36,402.91	6,568.87	798,278.79	118,662.08
ICT Firms	6	254.51	86.5	3,490	592.67
Other Firms	916	7,224.45	4,337.50	42,477	8,808.84
Wages	39.96	10,202.85	1,891.01	226,977.00	33,382.98
Population	57,313	399,813.68	269,699	1,838,882	416,483.91
Production Data					
Value Added	69.20	16,195.26	3,081.15	333,438.99	51,010.40
Capital	2,189	201,391.84	32,372.50	4,745,895	667,003.26
Employees	24	3,179.99	772.5	62,314	9,533.47
Investment Data					
Investment	-4,306.97	1,068.09	168.28	23,348.50	3,594.38

NOTE: Summary statistics for the Swedish Computer Service Industry 1996-2002. The data are from the merge between Financial Statistics(FS) and Regional Labor Statistics(RAMS) databases. There are 160 observations in 25 regional markets. The variables are aggregated at the county level. Sales, value-added, wages, capital, investment are measured in thousand 1996 SEK.

Table 3: Summary Statistics of IT Services Firms Grouped by Size

Variable	Minimun	Mean	Median	Maximum	Standard Deviation
A. Small size IT services firms: 0-19 employees					
Demand Data					
Sales	163.93	8,907.93	2,388.94	137,768.45	23,115.51
IT firms	6	229.67	80.5	3,061	526.24
Wages	39.96	2,258.71	627.41	37,210.65	5,989.27
Production Data					
Value added	69.20	3,721.18	1,101.67	52,299.44	9,323.55
Capital	1,263	47,820.12	14,168.50	739,642	118,627.24
Employees	17	798.55	273	10,861	1,855.07
Investment Data					
Investment	-234.19	248.85	74.78	4,770.86	660.46
B. Medium size IT services firms: 20-99 employees					
Demand Data					
Sales	29.19	8,616.47	2,279.74	145,898.22	23,682.26
IT firms	1	21.8	7	356	55.15
Wages	38.40	2,771.38	735.94	50,441.80	7,656.56
Production Data					
Value added	-54.74	3,782.43	1,102.12	61,821.02	9,836.86
Capital	341	41,396.75	8,994	828,553	115,149.54
Employees	20	845.67	260	13,128	2,102.38
Investment Data					
Investment	-183.24	244.63	43.59	5,752.71	702.84
C. Large size IT services firms: over 100 employees					
Demand Data					
Sales	313.51	33,115.55	6,124.54	514,612.13	93,380.25
IT firms	1	7.32	2	90	17.14
Wages	183.94	9,106.68	1,745.67	139,324.55	25,644.74
Production Data					
Value added	216.75	15,211.33	3,328.93	224,736.11	41,268.50
Capital	0	195,859.04	46,654	3,610,016	579,166.65
Employees	104	2,706.93	595.5	38,325	7,248.28
Investment Data					
Investment	-4,393.43	1,006.07	183.54	19,792.25	3,154.97

NOTE: Summary statistics for the Swedish Computer Service Industry 1996-2002. The data are from the merge between Financial Statistics(FS) and Regional Labor Statistics(RAMS) databases. There are 160 observations in 25 regional markets. The variables are aggregated at the county level. Sales, value-added, wages, capital, investment are measured in thousand 1996 SEK.

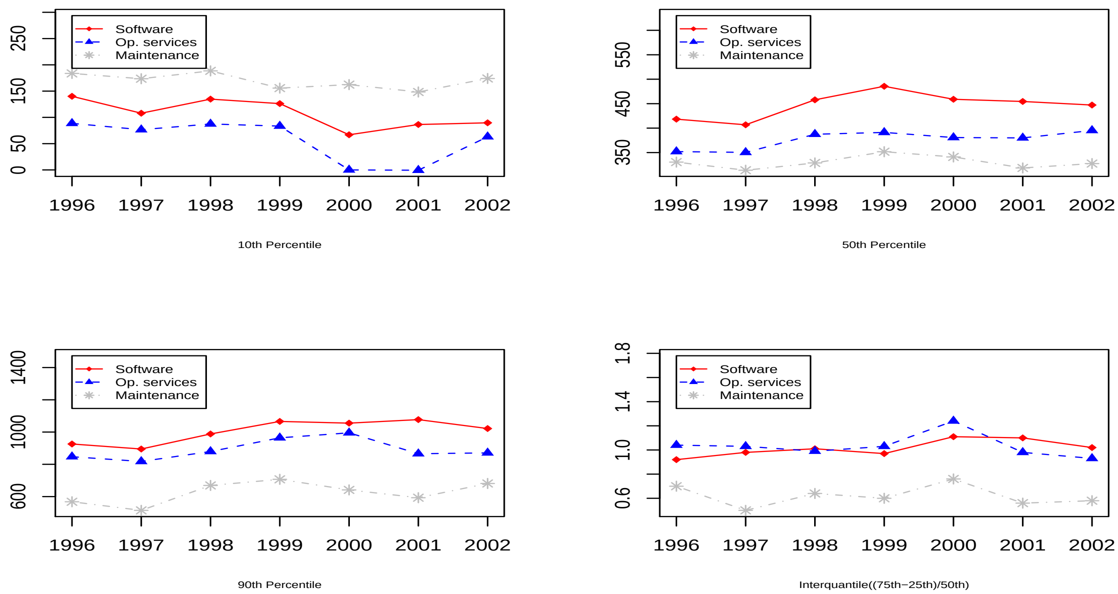

Figure 1: Evolution of the labor productivity percentiles and dispersion from 1996 to 2002.

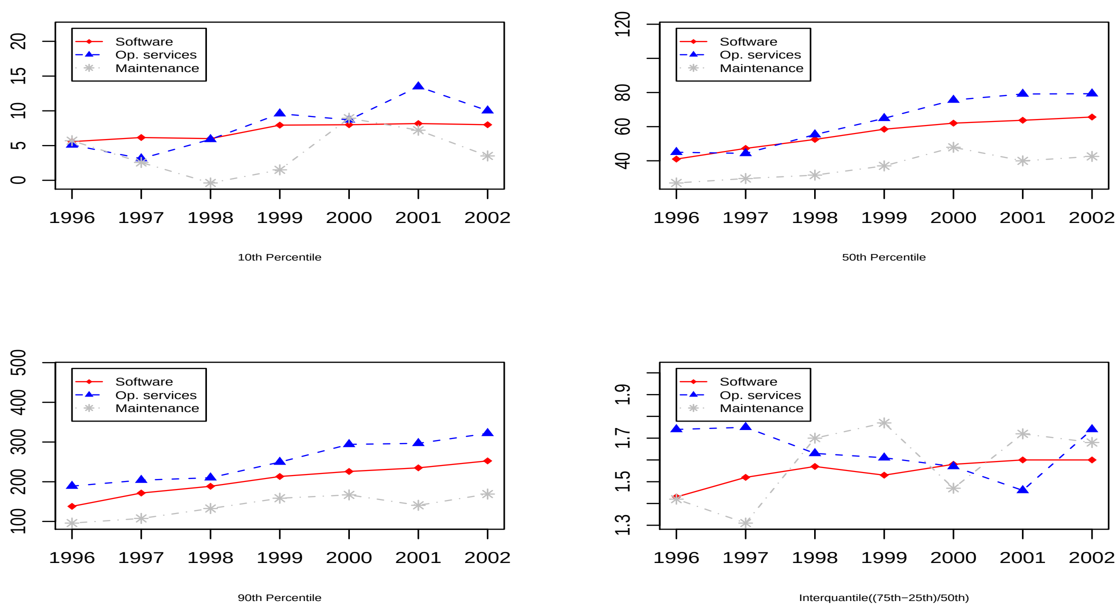

Figure 2: Evolution of the capital intensity percentiles and dispersion from 1996 to 2002.

Table 4: *IT Services Production Function Estimates*

	OLS all	ACF all	EOP software	EOP Op. services & maintenance
Log No Emp.	0.953	0.932	0.264	0.291
	(0.0056)	(0.0401)	(0.0092)	(0.0021)
Log capital	0.198	0.173	0.491	0.434
	(0.0036)	(0.0203)	(0.0067)	(0.0021)
Market output			0.076	0.344
			(0.002)	(0.008)
Scale	1.151	1.105	0.755	0.725
Demand			-13.12	-2
Mark-up			1.082	1.524
Sargan (p-value)			0.169	0.149
No. obs.	35,562	35,064	20,700	2,932

NOTE: OLS is ordinary least square regression including year dummies; ACF is Ackerberg, Caves, and Fraser(2006)'s two-stage estimation method; EOP is the semi-parametric estimation of equation (10) specified in Section 4, including selection. Current capital stock and previous labor are used as instruments in ACF. The standard errors in ACF are computed using bootstrap. Two-stage GMM is used in the EOP estimation. Reported standard errors (in parentheses) are robust to heteroscedasticity.

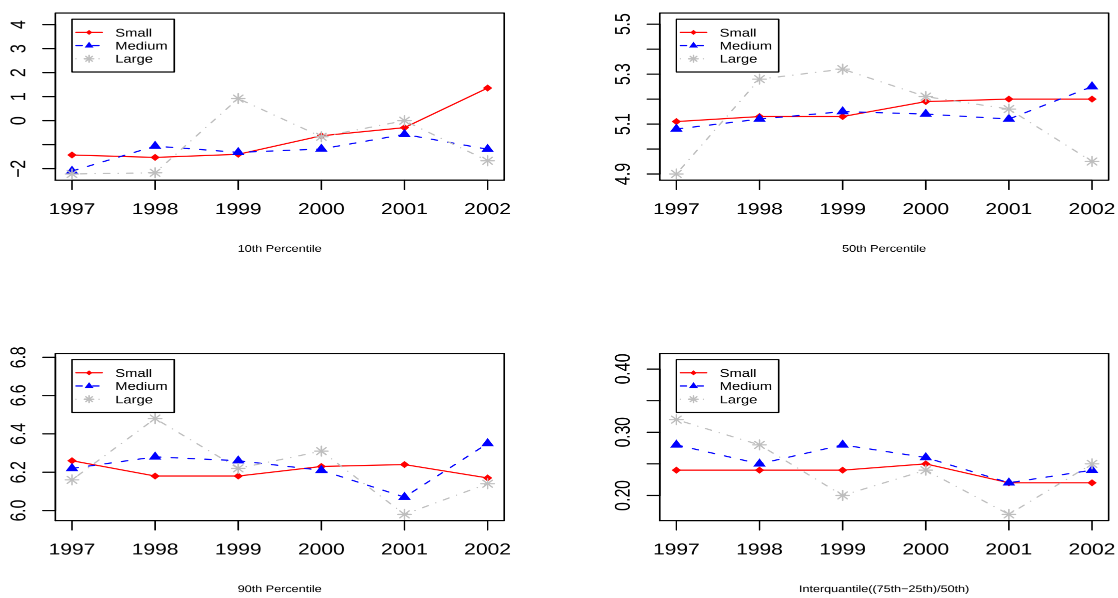

Figure 3: Evolution of the total factor productivity percentiles and dispersion for different size classes from 1996 to 2002.

Table 5: Revenue Functions

Variable	Small Firms	Medium Firms	Large Firms
Own productivity	0.019	0.196	2.878
	(0.002)	(0.014)	(0.367)
Rival's productivity	0.032	-0.012	-12.821
	(0.021)	(0.066)	(2.727)
Number of IT small firms	-0.001	-0.008	-0.0644
	(0.0001)	(0.0004)	(0.014)
Number of IT medium firms	-0.002	-0.009	-0.389
	(0.0008)	(0.003)	(0.119)
Number of IT large firms	0.045	0.280	3.271
	(0.005)	(0.020)	(0.699)
Dummy 2001 IT bubble burst	0.008	-0.694	-9.965
	(0.048)	(0.200)	(7.328)

NOTE: Standard errors are in parentheses.

Table 6: Policy Parameters: Small Size IT services firms: 0-19 employees

Variable	Exit Probit $P(exit\|X)$	Entry Probit $P(entry\|X)$	Entrants Investment	Incumbents Investment	Entrants Labor	Incumbents Labor
Own productivity	0.0007			5.598		0.0058
	(0.0068)			(0.499)		(0.0026)
Rival's productivity	0.023	0.0150	8.3340	-5.304	0.0130	-0.0686
	(0.087)	(0.0078)	(1.996)	(6.515)	(0.0291)	(0.0347)
Population	0.00006	-0.00004	0.0004	-0.0002	-0.0001	0.0001
	(0.000003)	(0.0007)	(0.0001)	(0.0002)	(0.00001)	(0.00001)
Number of firms	-0.0003	0.0032	0.0313	0.0187	0.0001	-0.00008
	(0.00002)	(0.00002)	(0.0046)	(0.0116)	(0.00001)	(0.000006)
Number of IT small firms	0.0004	-0.0023	0.0312	-0.247	-0.0011	0.00024
	(0.0001)	(0.0001)	(0.0443)	(0.092)	(0.0006)	(0.00049)
Number of IT medium firms	-0.0009	0.0008	3.6670	0.312	0.0137	-0.0014
	(0.0004)	(0.0003)	(1.3560)	(0.249)	(0.0019)	(0.0013)
Number of IT large firms	-0.0573	0.0217	-17.7970	3.664	-0.0026	0.0085
	(0.0029)	(0.0027)	(9.5320)	(1.784)	(0.0139)	(0.0095)
Dummy 2001 IT bubble burst	1.291	-0.4237	-16.400	-15.840	0.101	-0.0145
	(0.0198)	(0.0199)	(7.411)	(12.688)	(0.1083)	(0.0676)

NOTE: Standard errors are in parentheses.

Table 7: Policy Parameters: Medium Size IT services firms: 20-99 employees

Variable	Exit Probit $P(exit\|X)$	Entry Probit $P(entry\|X)$	Entrants Investment	Incumbents Investment	Entrants Labor	Incumbents Labor
Own productivity	-0.0179			-0.351		0.3747
	(0.0059)			(0.1636)		(0.0688)
Rival's productivity	0.0611	-0.0561	-0.0408	-0.0214	-0.0590	-0.9428
	(0.0252)	(0.0276)	(0.0227)	(0.7555)	(0.796)	(0.3177)
Population	0.00004	-0.00005	0.0097	-0.0094	-0.0004	-0.0002
	(0.00001)	(0.000001)	(0.0068)	(0.0033)	(0.00002)	(0.0001)
Number of firms	-0.00033	0.0003	0.5629	0.5647	0.0002	0.0011
	(0.00006)	(0.00006)	(0.4285)	(0.2069)	(0.00002)	(0.0008)
Number of IT small firms	0.0049	-0.0017	-2.4530	-2.641	-0.0081	-0.0053
	(0.0004)	(0.0005)	(3.983)	(1.595)	(0.0139)	(0.0067)
Number of IT medium firms	-0.0057	0.0016	2.838	6.141	0.0267	-0.0435
	(0.0014)	(0.0016)	(1.289)	(4.491)	(0.0451)	(0.0188)
Number of IT large firms	-0.0825	0.0027	1.204	-9.629	0.4076	0.1929
	(0.0098)	(0.0011)	(8.621)	(30.990)	(0.3021)	(0.1303)
Dummy 2001 IT bubble burst	1.370	-0.2667	-1.187	33.260	1.358	-0.5332
	(0.0731)	(0.0827)	(0.067)	(244.300)	(2.339)	(1.028)

NOTE: Standard errors are in parentheses.

Table 8: Policy Parameters: Large Size IT services firms: over 100 employees

Variable	Exit Probit $P(exit\|X)$	Entry Probit $P(entry\|X)$	Entrants Investment	Incumbents Investment	Entrants Labor	Incumbents Labor
Own productivity	0.0345			-382.500		15.260
	(0.0102)			(494.600)		(2.797)
Rival's productivity	0.123	0.0239	-1905.718	826.600	-51.438	-26.970
	(0.0695)	(0.0837)	(504.97)	(348.900)	(66.571)	(19.280)
Population	0.00001	-0.00004	0.106	0.0439	0.002	-0.0005
	(0.0001)	(0.00002)	(0.124)	(0.1197)	(0.002)	(0.0004)
Number of firms	-0.0007	0.0003	-7.199	-2.108	-0.125	0.0275
	(0.0001)	(0.0001)	(7.506)	(7.335)	(0.099)	(0.0414)
Number of IT small firms	0.0081	-0.0028	62.957	-1.923	1.076	0.1116
	(0.0123)	(0.0001)	(59.645)	(5.94)	(0.787)	(0.3220)
Number of IT medium firms	-0.0137	0.0046	41.256	190.00	-1.848	-0.702
	(0.0037)	(0.0038)	(155.454)	(163.100)	(2.051)	(0.922)
Number of IT large firms	-0.107	0.0351	-1098.623	115.800	-8.535	-2.326
	(0.0258)	(0.0276)	(1170.857)	(1178.00)	(15.447)	(6.659)
Dummy 2001 IT bubble burst	1.557	0.1538	1394.581	-988.200	-35.747	42.320
	(0.0197)	(0.0238)	(9783.344)	(938.70)	(129.072)	(56.200)

NOTE: Standard errors are in parentheses.

Table 9: Investment and Labor Costs Estimates for Different Size Classes

Variable	Small Firms	Medium Firms	Large Firms
Before the 2001 IT bubble burst			
Positive investment	1.31	1.53	1.11
Negative investment	1.07	1.10	0.69
Labor	1.03	1.08	1.14
Scrap	40.53	68.41	97.45
After the 2001 IT bubble burst			
Positive investment	1.10	1.44	0.96
Negative investment	1.04	1.23	0.76
Labor	1.24	1.31	1.32
Scrap	43.65	66.29	96.45

NOTE: Very preliminary results. Sunk costs are not estimated in this version .

Table 10: Investment and Labor Costs Estimates by Sectors

Variable	Software	Operational services	Maintenance and repair
Before the 2001 IT bubble burst			
Positive Investment	1.60	1.18	2.19
Negative Investment	1.10	1.07	1.12
Labor	2.62	2.47	2.33
Scrap	170.01	230.00	260.11
After the 2001 IT bubble burst			
Positive Investment	1.40	2.21	3.47
Negative Investment	1.01	1.05	1.09
Labor	3.86	3.95	2.51
Scrap	175.23	255.15	248.04

NOTE: Very preliminary results. Sunk costs are not estimated in this version .

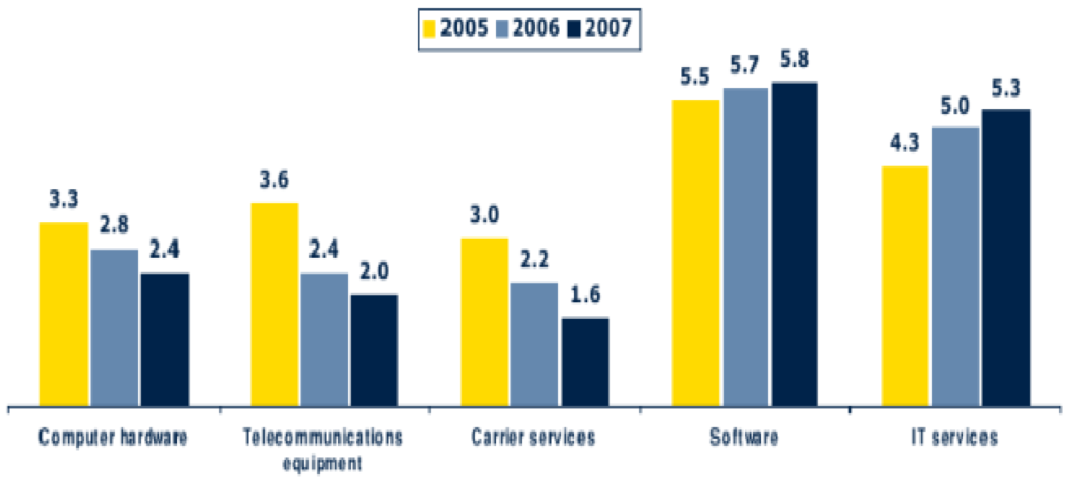

Figure 4: EU ICT, excluding Cyprus and Malta, market growth by segment, 2005-2007, in %. Source: EITO 2006 in co-operation with IDC.

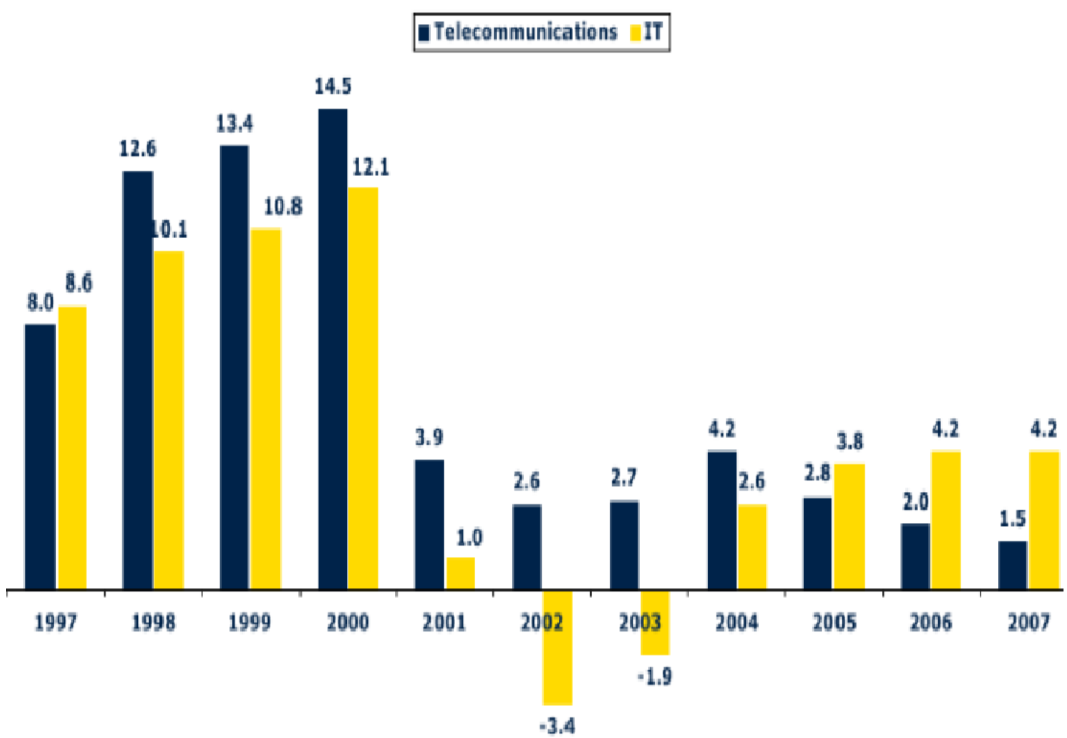

Figure 5: Western European ICT market growth, 1997-2007, in %. Source: EITO 2006 in co-operation with IDC.

Appendix A: In this section I describe the variables in the data. Value added is total shipments, adjusted for changes in inventories, minus the cost of materials. Real value added is constructed by deflating value added by a five-digit industry output deflater. The deflectors are taken from Statistics Sweden. The labor variable is the total number of employers. The total wages come from RAMS. I deflated sales, wages, and investment by the consumer price index(CPI) from IMF-CDROM 2005. The capital measure is constructed using a perpetual inventory method, $k_{t+1} = +(1-\delta)k_t + i_t$. Since the capital data distinguish between buildings and equipment, all calculations of the capital stock are done separately for buildings and equipment. As suggested by Hulten and Wykoff (1981) buildings are depreciated at a rate of 0.0361 and equipment at 0.1179.