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Productivity in Estonian Enterprises: The Role of Innovation and Competition

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Abstract

This paper provides some stylised facts about differences in labour productivity and total factor productivity (TFP) in Estonian firms and about the role of selected determinants of productivity differences. Enterprise level panel data of the whole population of Estonian firms from years 1995–2002 is used.

It appears that the variation of productivity indicators in Estonia is much greater than in Western Europe. Although there is a lot of entry and exit of firms, there is not much movement within the productivity distribution of surviving firms. It is found that both innovation and less concentrated market structure seem to be positively related to higher productivity of firms.

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Non-technical summary

This paper provides some stylised facts about differences in labour productivity and total factor productivity (TFP) in Estonian firms and about the role of selected determinants of productivity differences. The importance of innovation, product market competition/concentration of the sector and (based on earlier papers) the importance of knowledge diffusion in productivity improvements have been addressed.

Enterprise level panel data of the whole population of Estonian firms from years 1995–2002 is used in this paper. This firm level data from the Business Register of Estonia is then additionally merged with the Community Innovation Survey (CIS-3) data from year 2000. One advantage of this paper is that it can use data on not only manufacturing industry but on services sector firms as well.

It appears that the variation of productivity indicators in Estonia is much greater than in Western Europe. Only a small part of this large variance can be explained by region specific or sector specific characteristics alone. Although there is a lot of entry and exit of firms as documented by some earlier studies, there is not much movement within the productivity distribution of surviving firms.

It is found that both innovation and less concentrated market structure seem to be positively related to higher productivity of firms. Innovative firms appear to have higher TFP than the rest. However, a comparison of the results with some earlier studies on the effects of knowledge diffusion indicates that knowledge diffusion effects seem to be outnumbering these of innovation, possibly because of generally low extent of innovative activities in Estonian firms (at least according to the Community Innovation Survey for years 1998–2000).The lower concentration of a sector (implying higher competition) is ceteris paribus positively correlated with the productivity of the firms in this sector.

The results about the association between sector concentration/product market competition on one hand and productivity of firms on another are however, more controversial than the rest and require further analysis that would capture significantly more the various facets of product market competition.

Contents

1. Introduction

The usual short way to answer the question of how to improve productivity in a firm or the whole economy can be: by improving the quality of production inputs or using inputs more efficiently. It has also been assessed that productivity growth can arise from the market sorting of good and bad firms (Haskel, 2000; Ahn, 2002; Bartelsman et al., 2004). This proposition underlines the role of competition in productivity dynamics and has a lot to do with relatively recent developments in endogenous growth theory.

The neoclassical view has traditionally emphasized the role of capital accumulation, and later also the role of human capital in productivity improvements. Endogenous growth theory, which has developed rapidly since the work of Lucas (1988) and Romer (1986) however, gives a fairly more optimistic view of growth policies at both the macro and micro level. It underlines the role of R&D and innovation for productivity growth and has led micro data researchers to look more at the role of knowledge diffusion, innovation and also entry and exit of firms in productivity dynamics (Aghion and Howitt, 1992, 2005; Aghion and Griffith, 2005). Endogenous growth theory does not postulate that the sole determinant of growth is investment in R&D, but argues that capital accumulation cannot be seen as the sole determinant of growth. The important findings in papers that have been inspired by these ideas, based on population data about Estonian enterprises, say that both entry of high productivity firms and exit of low productivity enterprises contributes a lot to productivity growth in Estonia (Masso et al., 2004; Bartelsman et al., 2004).

In this paper the role of market sorting via product market competition[1] in the productivity improvements of firms is assessed. It is studied whether the level of innovation in the firm (or its R&D) is still an important contributor to productivity if several other possible factors are accounted for. Stylised facts about total factor productivity (TFP), labour productivity and capital intensity in the Estonian manufacturing and services sectors are also provided. I look at how much firms vary in their productivity in Estonia compared to Western European countries, and how surviving firms move in the productivity distribution over time — whether good firms remain the firms with the highest productivity; whether there is significant productivity upgrading of low productivity firms; or perhaps, productivity downgrading of good firms (e.g. due to the entry of new competitors; processes diverting from innovation to routine in existing firms, etc.).

A large enterprise level panel database of yearly data about all Estonian

[1]In the framework that is similar to that of the seminal paper by Nickell (1996) or Okada (2005).

firms from the period 1995–2002 is used in this paper. This dataset is merged with data from an innovation survey of the type of Community Innovation Surveys (CIS-3), in order to assess the effects of innovation.

The main findings are that productivity variation in Estonian enterprises is very high compared to the findings of similar studies of, for example, UK enterprise level data[2]. There is not much movement inside the productivity distribution of surviving firms — the most productive surviving firms usually remain the most productive and the least productive remain the least productive both at the beginning and the end of the period studied.

Both innovation and less concentrated market structure seem to be positively related to the higher productivity of firms. Innovative firms appear to have higher total factor productivity than the rest. Lower concentrations of firms in a sector are *ceteris paribus* positively correlated with the productivity of the firms in this sector.

The paper consists of 7 sections. Section 2 provides a brief overview of related literature. Section 3 describes the methods used in this paper and Section 4 describes the data. Section 5 then provides descriptive statistics based on enterprise level panel data. The results of the econometric analysis are given in Section 6. The last section concludes.

2. Competition, innovation and productivity — literature overview

The increasing interest in different factors of growth, other than capital deepening or savings, over the past two decades, both at macro, industry and firm level, can be traced to the development of endogenous growth theory (Lucas, 1988; Aghion and Howitt, 1992; Aghion et al., 2005). Endogenous growth theory underlines the role of innovation and competition and incentives to create knowledge for economic development. The core ideas of that strand of literature are very much related to the ideas of Joseph A. Schumpeter (1942)[3].

The Schumpeterian view emphasises the economy where competition is a "Darwinian struggle", the survivors of which are those who succeed in improving and creating new technologies (Howitt, 2004). The core of the Schumpeterian world is this "creative destruction", and the inclusion of his ideas in

[2]Until recently, large share of the analysis of productivity dispersion or analysis of the effect of competition on productivity has concentrated on UK data (e.g. Martin, 2005; Nickell, 1996).

[3]Also related to the ideas of evolutionary economics (Fagerberg, Dosi, Nelson, etc).

recent models of economic growth have underlined important possible implications for policy; whereas, neoclassical growth theory, in fact, left little room for policy making in accelerating the long-run productivity growth of a country.

Schumpeter's idea of creative destruction was (1942: 83; cited via Aghion and Howitt, 1992: 324):
The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumer's goods, the new methods of production or transportation, the new markets, ... [This process] incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism.

Schumpeter's ideas state that economic processes are organic and that the change comes from within the system and not simply as an exogenous factor. The change comes through innovations; hence, innovations and technology are endogenous to the system. Several models of economic growth have been developed based on Schumpeter's process of creative destruction, especially important is perhaps that of Aghion and Howitt in their famous article from 1992, which has increasingly been used as the basis for developing endogenous growth models.

One key conclusion from this strand of literature is that growth results from technological progress, which in turn results from technological competition among firms that generate innovations. Firms are motivated to innovate by higher payoffs, by the prospect of monopoly rents that can be captured by successful innovator firms (Howitt, 2006). Those rents (in the form of higher profits in the future etc) however, are temporary and will in turn be destroyed by the next innovations made by other firms (that make the former innovation obsolete; Aghion and Howitt, 1992). To be put shortly, this means that innovations are an important determinant of growth; however, the importance of product market competition and market structure is not so clear-cut. Thus, the theoretical models of industrial organization (for example Dasgupta and Stiglitz, 1980) and first generation models of endogenous growth theory (from the beginning of the 1990s, starting from Aghion and Howitt, 1992) implied that more intensive product market competition discourages innovation, and thus discourages growth as it reduces the monopoly rents from successful innovation.

The empirical evidence however, seems to a large extent to contradict this Schumpeterian idea. Empirical work on the effect of competition on a firm's performance (Nickell, 1996; Disney et al., 2003; Griffith, 2002; Okada, 2005) usually finds that increased competition promotes productivity growth among firms[4].

This discrepancy between theory and empirics has led the authors of models of endogenous growth theory to reconsider their models and include further channels for the positive effects of competition. One way to deal with this is to give greater consideration to the effect of weakening the barriers to entry. Howitt (2004, 2006) argues that these barriers can raise the cost of introducing new technology for outside firms, and thus reduce the incentive to engage in R&D and this may reduce the growth rate. Therefore, dismantling these barriers to competition may improve productivity growth.

The positive effects can also work via reducing the managerial slack due to increases in competition (Vickers, 1997). In the case of a monopolistic firm, some extra profits are captured by the managers of the firm in the form of managerial slack — that is, they do not have to work as hard as if there were competitors in the market.

In addition to that, competition may have an impact on the incentives of the workers. This follows if monopoly rents are shared with the workers of the firm and applies more for those firms where the unions are strong (Nickell, 1996). Then the extra rents from a monopoly may be captured in higher wages or lower incentive for workers than if there were more competition. Thus, there may sometimes be a direct link between the degree of product market competition and incentive to work among the workers. However, in the Estonian context, this link may not be very strong due to the minor importance of trade unions in the economy.

New generations of models of the endogenous growth theory (for literature overview see, for example, Aghion and Griffith, 2005) underline that competition could have a beneficial effect on productivity via the so-called "escape competition" effect. The firms, including not only new firms but incumbent ones as well, need to be innovative and reduce costs in order to survive. Engaging in innovation can be a way for incumbent firms to escape the competition. Aghion and Griffith (2005) and Aghion et al. (2005) show that more intense competition can yield more innovation, as it reduces pre-innovation rents more than it reduces post-innovation rents.

An important recent finding is that of an inverted U-shape relationship between competition and innovation (and thus possibly, the productivity of the firm) (Aghion, Bloom et al., 2005).
Source: Brouwer et al., 2004.

Figure 1 sums up the ideas that competition, innovation and productivity are all related to each other: innovation affects productivity, but may perhaps

[4]See also Table in Appendix 1 on selected findings of some empirical papers.

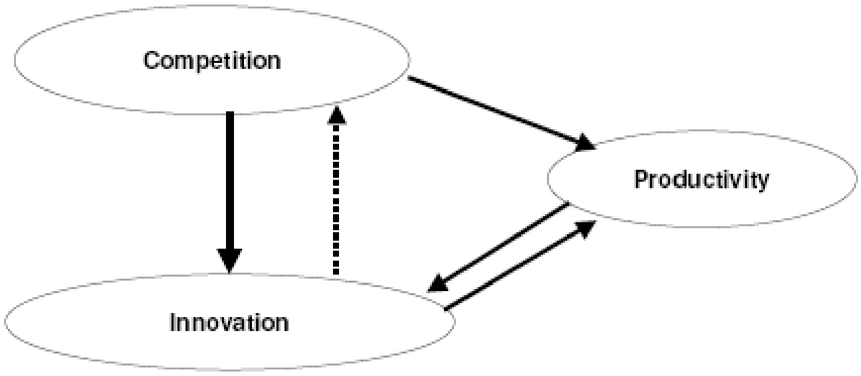

Figure 1: Relationship between competition, innovation and productivity

depend on the productivity of the firm (more productive firms are able to spend more on innovation). Competition affects both the innovation and productivity of the firm by either increasing it if positive effects dominate or decreasing it if negative Schumpeterian effect dominates. In addition to that, successful surviving innovators can affect the character of competition on the market and for the market (Brouwer et al., 2004).

It ought to be outlined here that the role of R&D and innovation in growth is not always self-evident. Endogenous growth theory has undoubtedly given a lot to our understanding of growth. However, there are some influential papers that are critical about this line of models. Growth accounting exercises, more recent than that of Solow (1957), by Young and Jorgenson (1995) and Jorgenson (1995) claim that technological progress may be a less important source of economic growth than capital accumulation.

Jones (1995) also argues, that the enormous increase in R&D in the post WWII period in the USA has not been accompanied by the corresponding rise in productivity that might indeed be expected based on Schumpeterian growth models. Jones (1995) thinks that this finding of relatively constant long-run growth in the face of enormous structural changes, such as trade liberalization, increases in years of schooling, increases in R&D etc., refutes many of the implications of endogenous growth theory.[5] Thus, the impact of innovation inputs or outputs on productivity, similarly to the effects of competition on productivity, may be not as clear as sometimes expected.

[5]However, the further tailoring of Schumpeterian style growth models has at least to some extent in recent years provided partial reconciliation of Jones's findings and endogenous growth theory's findings (Howitt 2004).

3. Methodology

In this report I look at both labour productivity and total factor productivity of the populations of firms in Estonia based on enterprise level panel data from 1995–2002. I outline selected descriptive statistics from this work and previous works on the productivity of firms in Estonia. Then I look at productivity dispersion — that is, the heterogeneity of firms in terms of productivity indicators, and concentrate on some determinants of the productivity differences between firms, including inputs like capital and labour and sector specific differences (in technology, etc.), and finally, endeavour to relate the remaining differences to the innovative activities of firms and the level of product market competition. Based on earlier studies I also outline, as an alternative method of improving the productivity of the firm, knowledge diffusion via FDI or trade, or via the international engagement of the firm in general.[6] Thus, I can discuss whether innovation or the diffusion of knowledge plays a greater role in productivity developments within Estonian firms.

In the context of the effect of competition, I concentrate more on "static" effects, by looking at different proxies of product market competition like concentration ratios and the Lerner index. The dynamic aspects of competition, such as the entry and exit of firms, have been outlined in a earlier article by Masso et al. (2004), where they find significant contributions from the entry and exit of firms to TFP and labour productivity growth inside Estonia. I look at whether other variables also capture the positive effect documented in their paper.

In the rest of the document I thus look at:

1. estimating the production function for individual sectors and calculating TFP based on the Levinsohn-Petrin (2003) model to account for the endogeneity of inputs and yield consistent estimates of the parameters of inputs in the production function;

2. endogeneity problems related to estimating the production function and the TFP;

3. how much the sectors inside the manufacturing and services sectors differ in terms of the technology used (i.e. I look at production function coefficients of single sub-sectors);

4. how much firms vary in their labour productivity and TFP indicators;

[6] Based on the findings of earlier related papers.

5. whether capital intensity and sector specific factors alone explain most of these differences;

6. what appear to be, within the limits of my data, the other main causes/ covariates for why some plants are more efficient than others — including the role of innovation, knowledge diffusion and product market competition;

7. how surviving firms move inside the productivity distribution of firms — do the most productive firms gradually fall down in the distribution, or is there significant productivity upgrading from firms that initially had low levels of productivity, provided that they survive in the market.

I measure the labour productivity of the firm as sales per employee or value added per employee. Total factor productivity is found as a residual from the estimation of a Cobb-Douglas type log-linear production function:

$$TFP_{ijt} = \frac{Y_{it}}{K_{ijt}^{\alpha_K} L_{ijt}^{\alpha_L}} \Rightarrow \ln TFP_{ijt} = \ln Y_{ijt} - \alpha_{Kj} \ln K_{ijt} - \alpha_{Lj} \ln L_{ijt} \quad (1)$$

where K_{ijt} is real capital, Y_{it} is real value added to the firm, L_{ijt} is employment, subscript *i* denotes the firm, *j* the sector, *t* denotes time. I find sector-specific coefficients of $\ln K_{ijt}$ and $\ln L_{ijt}$ by estimating the production function.

A thorough discussion of several problems related to the estimation of production functions is provided in the papers by Griliches and Mairesse (1995), Olley and Pakes (1996) and Levinsohn and Petrin (2003) — here I will briefly point out only some of these. Some of the important issues may be related to the quality of the data, the specification of the model, the simultaneity/endogeneity bias and the selection bias. The problems with the data could always be, for example, errors when measuring inputs or outputs. The issue of the measurement of capital can also be rather troublesome (Griliches and Mairesse, 1995).[7] Another important question in the literature is how to solve the endogeneity bias problem. In the context of the Cobb-Douglas production function (in logs) we have, in the case of two production factors capital *K* and labour *L*, for example:

$$\ln Y_i = \beta_1 \ln K_i + \beta_2 \ln L_i + \omega_i + e_i, \quad (2)$$

[7]For example, I would prefer to use data on the use of capital input over the stock of capital. However, the former is rarely available in practice.

where ω_i is the part of the error term that represents those inputs that are unobserved for the econometrician (e.g. managerial abilities), but may be known by the firm and thus may affect the optimal choice of other observed inputs *K* and *L*. If indeed ω_i is known to the firm when making decisions on optimal choice *(K; L)*, then *K* and *L* will be correlated with ω_i and the OLS estimation will yield biased results.

Recent contributions to solving this problem include semi-parametric estimation procedures, particularly, the methods developed by Olley and Pakes (1996) or Levisohn and Petrin (2003). The latter of these will also be used for estimating the coefficients of inputs in this paper. An alternative option would have been to impose constant returns to scale and calculate the coefficients of the log of *K* and *L* by the so-called index number approach and then, again, find TFP as a residual from the logarithmic form of the Cobb-Douglas type production function. Based on Estonian enterprise level data, this was done by Masso et al. (2004). However, this assumption of constant returns to scale might obviously not hold. In the index number approach the parameters of the log of *K* and *L* represent industry cost shares. The industry capital share would then be measured as a residual from the labour cost share — that is, $\alpha_K = 1 - \alpha_L$, thus this parameter estimate may be fairly different from the true parameter of capital, due to this assumption of constant returns. Some authors have also tested different ways to estimate the TFP: the index number approach versus the Levinsohn-Petrin model and the translog production function (for example, Girma and Gong, 2005). Girma and Gong (2005) find that the index number method can provide significantly misleading measures of TFP and thus misleading measures on the effects of different other factors on the TFP of firms. Also Wooldrige (2005) finds that the Levinsohn-Petrin approach is probably among the most suitable methods for estimating the production function.

One way to address the endogeneity problem would be to use panel data instead of cross-section data and to control for firm specific time invariant effects by employing, for example, a fixed-effects model. Then one estimates ω_i as fixed effects, and provided that there is enough reason to think that ω_i (managerial abilities etc) is something firm specific and invariant over time, *K* and *L* are no longer correlated with the error term (Levinsohn and Petrin, 2003). However, this last assumption is credible only in the case of a very short time span of the panel. This is not the case here. Recent papers in econometric methods for production function estimation stress that a better way to control for the endogeneity bias is by using the Levinsohn-Petrin semi-parametric estimation method, with some measure of materials as a proxy to account for ω_i. Also, I note here that the fixed effects model often underestimates the coefficient of capital in the estimation of a Cobb-Douglas type production function

(Levinsohn and Petrin 2003). I can check this later on based on my data.

Given the above, I follow a two-step approach. At first, I estimate the TFP as a residual from the logarithmic form of the Cobb-Douglas production function by using the Levinsohn-Petrin (2003) procedure and allowing different coefficients of the logs of capital and labour in the production function for different sectors (at NACE 2-digit level):

$$\ln Y_{ijt} = \beta_0 + \beta_1 \ln K_{ijt} + \beta_2 \ln L_{ijt} + \omega_{ijt} + \eta_{ijt}, \tag{3}$$

where $\ln Y$ is the log of value added, ω_{ijt} is the productivity component of the error term that is allowed to be correlated with the input choices, and η_{ijt} is an error term that is uncorrelated with input choices. The Levinsohn-Petrin semi-parametric estimation method estimates this equation with materials as a proxy to account for ω_{ijt}. This method allows for economies of scale different from constant returns. By estimating separate production functions for all sectors, one can consider in a more consistent manner the individual heterogeneity in the data. Indeed, the findings, presented later on, will prove that estimating one coefficient over all manufacturing or services firms could potentially lead to *biased* findings about the TFP of firms, as sub-sectors have large variations in capital and labour coefficients, indeed these can be quite different from the overall average of the manufacturing industry.

The TFP can then be calculated from the estimated equations as follows:

$$\mathit{TFP}_{ijt} = \exp\left(\ln Y_{ijt} - \beta_{1j} \ln K_{ijt} - \beta_{2j} \ln L_{ijt}\right) \tag{4}$$

In the second step, I regress the log of the TFP on competition related and other control variables:

$$\ln TFP_{ijt} = \beta_3 X_{ijt} + \alpha_j + \alpha_t + \epsilon_{it} \tag{5}$$

The vector X_{it} captures competition related variables and possible other control variables, and α_j with subscript *j* indicates industry specific effects. Note, however, that when estimating the TFP premium associated with innovating, only cross section data can be used, thus there the time dummies are dropped.

The competition related variables that are traditionally used in the literature assessing the effects of product market competition on productivity (Nickell, 1996; Griffith, 2002; Okada, 2005, etc) have in the past been: industry concentration ($CONC_{jt}$) at the 3-digit level calculated as the Herfindahl index[8];

[8]The value of the Herfindahl index is the sum of the squares of the market shares of all

industry import penetration (*IMPORT*$_{jt}$) at the 2-digit sector level; the "market share" of the firm (*MSHARE*$_{ijt}$) based on a 3-digit (or 4-digit) definition of sector; and a firm level proxy for the Lerner index (*LERNER*$_{ijt}$). The market share variable and Lerner index are firm specific variables. As Estonia has a very open economy, I will also add the sector level ratio of exports to sales (*EXP*$_{ijt}$)(for NACE 2-digit level sectors) as one potential openness indicator. Import penetration is also included as a measure of foreign competition. The industry level import and export data was available for the manufacturing sectors, but not for the services sector.

Note that both the concentration index and market share may often be misleading measures of competition as they are related to some specific classification of the sectors. The Lerner index, which measures the market power of each individual firm, is more trustworthy as it is not related to some specific classifications of sectors. Under the assumption that average variable cost provides a good approximation of marginal cost, the proxy of the Lerner index for each firm can be measured as sales minus the cost of wages and the cost of intermediate inputs divided by sales (see Griffith, 2002 or Disney et al., 2003). Note that sales equals price times quantity $P_{ijt}Q_{ijt}$, and the cost of wages plus the intermediate inputs here equals average variable costs times quantity ($AVC_{ijt}Q_{ijt}$).

Thus the firm specific Lerner Index can be written as:

$$LERNER_{ijt} = \frac{P_{ijt}Q_{ijt} - AVC_{ijt}Q_{ijt}}{P_{ijt}Q_{ijt}} = \frac{P_{ijt} - AVC_{ijt}}{P_{ijt}} \quad (6)$$

Inserting the abovementioned measures of competition into vector X_{ijt} in equation (5), (with *MSHARE* and *LERNER* lagged by two periods due to a possible endogeneity problem) and taking first differences of equation (5) in order to eliminate the fixed effects, yields the following:

$$\begin{aligned} \Delta \ln TFP_{ijt} &= \beta_{11}\Delta MSHARE_{ijt-2} + \beta_{12}\Delta LERNER_{ijt-2} + \\ &+ \beta_{13}\Delta CONC_{jt} + \beta_{14}\Delta IMPORT_{jt} + \beta_{15}\Delta EXP_{jt} + \\ &+ \mu_t + \omega_{it} \end{aligned} \quad (7)$$

This framework is quite similar to that used in Nickell (1996), Disney et al. (2003), Griffith (2001) and Okada (2005), using UK or Japanese enterprise level panel data (with the exception that I also add the export orientation sector level variable). I would expect an inverse relationship between the Lerner

firms in an industry: the Herfindahl index has values between 0 and 1. It is equal to 1 in the case of the most concentrated market structure (i.e. with one firm).

index, concentration ratio and market share on one hand, and the productivity of the firm on the other. Also, former findings in other countries have usually indicated negative coefficients for at least some of these variables.

4. Data

For the analysis in this paper, different enterprise level datasets have been merged. The main database used in the empirical analysis, and for estimating the models as outlined above, was sourced from the Business Register of Estonia. It covers yearly balance sheet and income statement data for the population of Estonian firms for the period 1995–2002. I have information about up to 41,000 firms per year. The number of firms at the beginning of the period is about 15,000. The panel data allows to study both the manufacturing (NACE 2-digit code between 15 and 37) and services sectors (NACE 2-digit code between 50 and 74). The majority of the related studies in the world have so far concentrated on analysing manufacturing industry data. It should be mentioned however, that the commercial banks (due to size effects and sector specifics) have been excluded from the analysis of the services sector.

As a co-product of this paper, the CIS type innovation survey data has also been merged with the main Business Register Database. However, the CIS-3 survey covered innovative activities of about 3,490 firms and most of the data on innovation is available only as cross section data. For example, it provides answers to questions like "Did your firm engage in product innovation in the years 1998–2000?" (Kurik et al., 2002)[9].

I measure capital as the sum of tangible and intangible fixed assets minus goodwill. The following deflators are used to correct for inflation. Output, valued added and intermediate inputs are deflated by respective deflators of the system of national accounts provided by the Statistical Office of Estonia. The deflators are available for 16 sectors (that corresponds to the top level in ISIC

[9]This innovation survey defines innovations as follows. Technological innovation — implemented technologically new products, processes or services and significant technological improvements in products, processes or services. It requires an objective improvement in the performance of a product or in the way in which it is produced or delivered. An innovation has been implemented, if it has been introduced to the market — via product innovation, or within the production process — process innovation. The product, service or process should be new (or significantly improved) to the enterprise, but it does not necessarily have to be new to the enterprise's market (Kurik et al., 2002).

Research and development (R&D) were defined in the same survey as follows: creative work undertaken on a systematic basis in order to increase the stock of knowledge, and the use of this stock of knowledge to devise new applications, such as technologically new or improved products and processes.

Rev. 3.1). Capital is deflated using the gross capital formation price index (available only for the total economy). The deflators are based on the following price indices: consumer price indices according to commodity groups and fields of activity, producer price indices according to fields of activity, construction price indices and export and import price indices. It is assumed that production and value added change in the same way (single deflation; double deflation assumes the compilation of input-output tables). For more information, see also the National Accounts of Estonia (2003). For a more thorough description of the characteristics of the Business Register database consult also the article by Masso et al. (2004).

5. Descriptive statistics about the heterogeneity of productivity among firms

The estimated coefficients of the log of capital and labour in the production functions of separate sectors are presented in Tables 1 and 2, for both the manufacturing and services sectors.

We can see that the findings of the fixed effects model (FE) and the Levinsohn-Petrin (LP) model differ significantly; thus, accounting for endogeneity of inputs seems to be important and methods not accounting for this can yield inaccurate estimates of coefficients of inputs and thus inaccurate estimates of TFP for individual firms. Levinsohn and Petrin (2003) argued that the FE model often underestimates the coefficient of capital in a Cobb-Douglas type production function. If I calculated only one pair of coefficients for the whole manufacturing or services industry, this would also be the case in Estonia. However, if I calculate separate production functions for 2-digit level subsectors, we see that in some industries the coefficient of capital in the LP model is lower and in some sectors it is higher than in the FE model. Endogeneity of inputs does appear to distort the estimated coefficients in the FE model.

Over the last decade, researchers have started to document the distribution of productivity among firms in the economy (Oulton, 1998; Martin, 2005). The reason why this is a relatively recent development is that micro datasets that were usually unavailable for researchers before have become increasingly available. Part of this development can also be explained by the development of computer power to process large panel datasets. Productivity spreads [10] can be a potential source of aggregate productivity improvement, and the aim of policy might be to concentrate on bringing the laggard firms up to the stan-

[10]Productivity spread can be defined as the distance between the best and the worst performing firms in an industry.

Table 1: Descriptive statistics — coefficients from a Cobb-Douglas type of production function (relaxing the assumption of CRS) in manufacturing sectors

Sector	Levinsohn-Petrin (2003) method				Sector name	Sector	Fixed effects model			
	Log L		Log K				Log L		Log K	
	Coef	st.err	Coef	st.err			Coef	st.err	Coef	st.err
15	**0.4396**	0.0414	**0.2812**	0.0657	Food processing	15	**0.6852**	0.071	**0.2042**	0.0208
17	**0.5353**	0.044	**0.2289**	0.0667	Textiles	17	**0.622**	0.0685	**0.2475**	0.0357
18	**0.725**	0.0385	**0.1624**	0.0439	Wearing apparel	18	**0.6871**	0.0751	**0.1972**	0.0297
19	**0.5378**	0.0757	**0.1638**	0.1447	Leather etc.	19	**0.4994**	0.1544	**0.2061**	0.0702
20	**0.4543**	0.0323	**0.298**	0.033	Wood processing	20	**0.7258**	0.0652	**0.3074**	0.0262
21	**0.287**	0.088	**0.2861**	0.1281	Paper	21	**0.9106**	0.1955	**0.2953**	0.0662
22	**0.5106**	0.0456	**0.1655**	0.051	Printing	22	**0.3196**	0.0648	**0.2248**	0.0271
24_25	**0.639**	0.0894	**0.3265**	0.0684	Chemicals and plastics	24_25	**0.5853**	0.1362	**0.2746**	0.0795
26	**0.4756**	0.0622	**0.3641**	0.1116	Construction materials etc	26	**0.7318**	0.13	**0.1767**	0.0684
28	**0.5226**	0.0312	**0.2223**	0.0513	Metal products	28	**0.6602**	0.0612	**0.2624**	0.0259
29	**0.4901**	0.0475	**0.389**	0.0772	Machinery, equipment	29	**0.4356**	0.0957	**0.313**	0.0536
30	**0.3332**	0.2069	0.576	0.3051	Computers, office machines	30	**0.9349**	0.1424	**0.4723**	0.1066
31	**0.6838**	0.0755	**0.2694**	0.08	Other electrical machines	31	**0.9534**	0.1969	**0.2831**	0.0649
32	**0.6077**	0.0669	**0.2556**	0.1478	Radio, telecomm. equipment	32	**0.5964**	0.2	**0.3049**	0.0796
33	**0.5833**	0.0983	**0.2153**	0.1372	Medicine tech., optics etc	33	**0.769**	0.0936	**0.1147**	0.0399
34	**0.3124**	0.1015	**0.099**	0.2926	Other transport vehicles	34	**1.6549**	0.3688	**0.0473**	0.1
36	**0.4572**	0.0441	**0.3795**	0.036	Furniture etc.	36	**0.5605**	0.0595	**0.3839**	0.0294
37	**0.5495**	0.1697	**0.9472**	0.2648	Recycling	37	**0.8293**	0.26	**0.6526**	0.1837

Source: own calculations based on database of manufacturing and services sector enterprises from the Business Register of Estonia.

dards of the leading firms. Productivity spreads have so far received considerable analysis and attention from economic policy makers in Western Europe (Martin, 2005) and less analysis in transition economies.

The stylised facts about productivity in the Estonian manufacturing and services sectors, apart from the fact that productivity has grown significantly in these sectors, is that there is a very large variation in terms of productivity among firms (see Table 3). The mean value for value added per employee in the manufacturing industry was 64,180 EEK in 1995 and 108,480 EEK in year 2002 according to the calculations based on data from the business register. The corresponding figures for the services sector were 78,170 EEK in 1995 and 121,640 EEK in 2002. Table 3 shows that labour productivity has on average been higher in the services sector than in manufacturing.

Table 2: Descriptive statistics — coefficients from a Cobb-Douglas type of Production function (relaxing the assumption of CRS), LP method vs simple FE model in the services sectors

Sector	**Levinsohn-Petrin (2003) method**				Sector name	Sector	**Fixed effects model**			
	Log L		**Log K**				**Log L**		**Log K**	
	Coef	st.err	**Coef**	st.err			**Coef**	st.err	**Coef**	st.err
50	**0.4652**	0.023	**0.2629**	0.0282	Retail trade 1	50	**0.6929**	0.0414	**0.2618**	0.0168
51	**0.3186**	0.0173	**0.2408**	0.0164	Wholesale trade	51	**0.7371**	0.0273	**0.2115**	0.0123
52	**0.3629**	0.0236	**0.225**	0.0154	Retail trade 2	52	**0.6413**	0.0229	**0.1676**	0.0084
55	**0.6239**	0.0236	**0.2013**	0.0249	Hotels, restaurants	55	**0.5497**	0.0404	**0.1786**	0.0168
60	**0.3885**	0.0244	**0.4535**	0.0339	Transport and transit	60	**0.5415**	0.0365	**0.3887**	0.022
63	**0.7391**	0.0404	**0.2838**	0.0562	Transport related services activities	63	**0.7129**	0.0724	**0.2465**	0.034
64	**0.4452**	0.0685	0.1379	0.1618	Communication services	64	**0.2638**	0.160	**0.4744**	0.0802
70	**0.54**	0.024	**0.2877**	0.0427	Real estate, business services etc	70	**0.4059**	0.0447	**0.2065**	0.0318
71	**0.4568**	0.0634	**0.3313**	0.1249	Renting and leasing of machinery and equipment etc	71	**0.7027**	0.1585	**0.3604**	0.0509
72	**0.7698**	0.0494	**0.2737**	0.0773	Computer services	72	**0.7849**	0.0726	**0.1965**	0.0344
74	**0.6796**	0.0131	**0.1921**	0.0267	Other business services , other services	74	**0.6082**	0.0298	**0.1972**	0.0132

Source: own calculations based on the database of manufacturing and services sector enterprises from the Business Register of Estonia

However, inside this mean value of productivity, there is considerable heterogeneity within both manufacturing and services sectors. In order to take a look at the productivity spread underlying these averages, I have ranked the firms of the database according to their productivity and compared the productivity of the firm at the 90th percentile with the firm at the 10th percentile of the ranking. This gives us information about the productivity differences without relying too much on the best and worst firms, as the best and worst in such a database can be a result of data errors. In order to avoid including potential data errors in this analysis, I have for most of the calculations excluded the top 1 per cent and the lowest 1 per cent of firms in the distribution of productivity from the database.

Table 3 shows that the labour productivity spread in manufacturing, if measured as sales per employee was 18.6 times in 1995 and 12.4 in 2002. For the value added based measure, the corresponding figures were 13.8 in 1995 and 9.2 in 2002. Thus the productivity spread of firms seems to be falling over time in the manufacturing industry. A similar tendency also holds for the ser-

Table 3: Productivity spread in Estonia in 1995 and 2002 (EEK)

	Year	Sales/employees	VA/employees	Capital intensity	
Manufacturing	1995	191232	64182	41862	Mean
		8590	2522	5080	st. error
		18.6	13.8	80.1	p90/p10
	2002	326341	108477	71287	Mean
		6829	2075	7300	st. error
		12.4	9.2	42.3	p90/p10
Food processing	2002	383845	88246	93044	Mean
		24089	5390	7423	st. error
		385	303	371	No of firms
		11.7	7.6	37.0	p90/p10
Services	1995	311631	78174	56260	Mean
		7156	1708	6601	st. error
		25.0	21.4	108.9	p90/p10
	2002	429743	121636	188072	Mean
		4985	1214	19166	st. error
		21.5	14.5	99.8	p90/p10

Note: p90/p10 is the ratio of the highest decile to the lowest decile.
Source: own calculations based on the database of manufacturing and services sector enterprises from the Business Register of Estonia

vices sector. The variation of labour productivity in the manufacturing sector on average is significantly lower than in the services sector. A similar finding was presented by Oulton (1998) for the UK. This may be due to international competition effects as these may be larger for manufacturing firms.

If we take a look at the TFP spread (see Table 4) it appears that, while the spread was quite similar in 1995 in the manufacturing and services sectors, by 2002 the differences had, on average, decreased significantly in manufacturing, but had grown in the services sector. It is important to note that these productivity spreads in Estonia seem to be much higher than in Western European countries. The study by Haskel (2000) presents that the corresponding productivity spread (90th percentile / 10th percentile) was 4.5 in the manufacturing industry in 1992 and that it had stayed roughly the same compared to 1980. Martin (2003) presents evidence that the productivity spread in Finland and the Netherlands is of similar size to the UK.

What could explain such large productivity spreads? One possible explanation could be the coverage of firms, aggregating very different sectors together as one manufacturing sector. The data discussed so far is for services or manufacturing sectors. The averages of these two major sectors cover many very different sectors, which have very different technologies and labour or capital intensities — thus exhibiting potentially significantly varying productivity levels that the average in the manufacturing or services industry hides.

Table 4: TFP spread, the ratio of the highest decile to the lowest decile

	Year	p90/p10 of TFP
Manufacturing	1995	30.7
	2002	23.1
Food processing	1995	15.8
	2002	7.3
Services	1995	30.4
	2002	38.9

Source: own calculations based on the database of manufacturing and services sector enterprises from the Business Register of Estonia

Indeed, there is much variation in terms of productivity inside both the manufacturing and the services sector. Table 3 also presents the corresponding statistics for the food processing industry as an example. We see that the productivity spread inside that industry is only a little bit smaller than in manufacturing on average. The spread in that sector and in other sub-sectors as well is still significant and it indicates that sector specific factors alone do not explain most of the productivity variety among firms; other factors need to be identified as well.

In the case of labour productivity measures, the major contributor to productivity is certainly the capital intensity of the firm. Employing more capital per employee raises labour productivity. The capital intensity of firms in Estonia varies even more than labour productivity or the TFP. The fact that there is still considerable variation in TFP however, underlines that the capital-labour ratio does not only by itself explain these large differences in productivity.

Another explanation could be that firms in different regions exhibit different productivity. One finding of our analysis was also that firms in Tallinn tend, on average, to have higher productivity than the rest. However, the productivity variation is significant also in different regions.

The sizeable productivity spread in Estonia may also have policy implications for policy makers. This heterogeneity can however, be an indicator of both good and bad circumstances at the same time (Martin 2005). Part of it is "bad" in the sense that, to some extent, it shows a shortage of competition, so that laggard firms are not forced to exit but carry on binding productive resources. (Part of) it may be, however, "good" as it may alternatively reflect ongoing trials and errors of firms, innovations and selection of the best firms in a competitive environment.

Masso et al. (2004) and Bartelsman et al. (2004) have also underlined entry and exit as important contributors to productivity growth in Estonia. Their finding in these two papers was that the entry of high productivity firms and the exit of "bad" firms, contributes a lot to productivity growth in Estonia. The findings about the numerical values of the contributions of entry and exit or about Estonian results in international comparison vary to an extent in these two studies. Bartelsman et al. (2004) show that entry and exit are important for all countries — Estonia is not particularly different from other cases, except that there are many countries where entry and exit contributes more to productivity growth than in Estonia. The findings of Masso et al. (2004) and Bartelsman et al. (2004) may to some extent support the idea of the presence of a "good" spread as the presence of a continuous selection process.

These papers have, by studying the entry and exit effects, covered in fact some dynamic effects of competition on productivity. One way to extend their analysis is to look at more standard measures of competition as explanatory actors of productivity (see next section), or to take a look at the productivity dynamics in surviving firms. Thus I try to answer the question: how do surviving firms move inside the productivity distribution? The movements of firms underlining these spreads of productivity, as presented in Tables 5 and 6 (and Appendix 2 and Appendix 3), can potentially differ and can have different policy implications as well (Haskel 2000).

Table 5: TFP transition matrix, manufacturing sector 1995–2002 (percentages)

	End of the period						
	Quintiles	The lowest	2nd	3rd	4th	The highest	Total
Beginning of the period	The lowest	53.1%	18.4%	20.4%	4.1%	4.1%	100.0%
	2nd	30.7%	42.7%	16.0%	6.7%	4.0%	100.0%
	3rd	13.0%	26.1%	27.5%	27.5%	5.8%	100.0%
	4th	6.3%	11.3%	22.5%	41.3%	18.8%	100.0%
	The highest	0.0%	3.1%	5.1%	26.5%	65.3%	100.0%

Note: surviving firms.
Source: own calculations based on the database of manufacturing and services sector enterprises from the Business Register of Estonia

I follow Haskel (2000) and Baily et al. (1992) in outlining the different possible ways this can occur. Possibility 1 is where firms enter the market with different productivity levels and each firm stays relatively in the same place in the productivity distribution over time. Possibility 2 is that firms enter with similar initial productivity, but some firms upgrade and some downgrade in terms of efficiency, with those falling gradually down the productivity distribution eventually exiting. Possibility 3 (not likely in the case of Estonia) is that firms are fundamentally the same, but suffer from different productivity shocks that make some firms at some period do well and others do badly. Another option is that firms enter with different levels of efficiency of produc-

Table 6: TFP transition matrix, services sector 1995–2002 (percentages)

	End of the period						
	Quintiles	The lowest	2nd	3rd	4th	The highest	Total
Beginning of the period	The lowest	53.8%	24.4%	13.1%	5.6%	3.1%	100.0%
	2nd	12.9%	37.4%	29.0%	11.6%	9.0%	100.0%
	3rd	10.1%	27.8%	29.3%	21.7%	11.1%	100.0%
	4th	5.6%	10.7%	21.0%	37.3%	25.3%	100.0%
	The highest	3.7%	5.6%	9.7%	20.6%	60.4%	100.0%

Note: surviving firms.
Source: own calculations based on the database of manufacturing and services sector enterprises from the Business Register of Estonia.

tion, but their efficiency gradually fades as the firm ages — that is, firms move down the productivity distribution as they mature, and eventually exit.

Tables 5 and 6 (and Appendix 2 and Appendix 3) address these different possible scenarios and test these possibilities. They map the productivity transition between 1995 and 2002 of surviving firms[11]. Here in the body of the text the productivity transition tables for TFP in manufacturing and services sectors are presented. The corresponding tables for labour productivity transitions can be found in the Appendix 2 and 3, the results are most similar to the TFP case.

The left most column shows the productivity quintiles for 1995, the upper most row shows the quintiles in 2002. The numbers in the cells denote the transition probabilities from the corresponding quintile group in 1995 to the corresponding quintile group in 2002. That means that the top left cell shows the fraction of plants beginning in the lowest productivity quintile in 1995 that also remained in the lowest productivity quintile in 2002.

Based on Tables 5 and 6, there appears to be a good amount of persistence in the position of surviving firms in the productivity distribution. Not much upgrading or downgrading inside the distribution occurs, firms that start off in one part of the productivity distribution tend to stay there also in the end of the period of analysis (as indicated also by the highlighted cells in the transition matrices). Possibility number 1 therefore, gets the most support.

In the manufacturing industry, 65.3 per cent of surviving firms that had the highest total factor productivity level in 1995 also had the highest productivity in 2002; the corresponding figures for persistence in the lowest TFP quintile was 53.1 per cent in manufacturing. The findings in the services sector are

[11] The productivity transition matrices calculated for shorter time periods also look similar to these presented here.

similar. The number of the best or the worst surviving firms moving away from their initial status group is relatively small (see Tables 5 and 6). Thus “good firms” tend to stay “good firms” and “bad firms” either exit (Masso et al. 2004) or stay “bad firms” if they survive. These findings are again quite similar to those in the UK (Disney et al., 2003; Haskel, 2000). The fact that there is significant persistence in terms of their position in the bottom quintile gives some evidence of the abovementioned “bad” productivity spread, with some productive resources persistently bound in low productivity firms, while they could be used more efficiently elsewhere. Thus, clearly, this large productivity spread has both a negative and positive component (also positive, as indeed a lot of entries and exits of firms take place, as indicated by Masso et al., 2004). The continued need to promote competition and keep barriers to entry or exit low could be one policy implication from this analysis.

The main findings of this section were that there is a very large productivity spread among Estonian firms that is larger than in Western European countries. The sector specific factors, region specific factors and capital intensity explain only part of the variation in terms of labour productivity or TFP. There seems to be significant persistence in the firm’s position in the productivity distribution. One interesting finding from this section was that manufacturing firms have significantly lower productivity variation than enterprises in the services sectors — this may possibly be due to international competition effects as these may be larger for manufacturing firms.

6. Analysis of selected determinants of productivity

According to the Estonian CIS-3 type innovation survey “Innovation in Estonian enterprises in the period 1998–2000” (Kurik et al., 2002):

- one-third of enterprises developed new products or improved their products or technological processes during the period;
- enterprises were a bit more product innovative than process innovative;
- half of all innovators develop their innovations themselves and a quarter in cooperation with others; 14% of all innovators introduced products that were also new to their markets. Among the product innovators, the share of novel innovators was 52%;
- 16% of enterprises have uncompleted projects and 4% have abandoned their innovation projects.

The unconditional mean analysis in Table 7 indicates that innovative firms (firms that had product or process innovation in the years 1998–2000) had higher productivity in 2000 than the remaining firms. Due to the limitations of the sample data on innovative activities, only cross-section data for 2000 can be used here. The number of observations is thus significantly lower than in former tables based on Business Register data. However, for analysis of competition effects, the entire data on the population of firms can be utilised.

Table 7: Unconditional mean analysis of productivity according to the innovativeness of the firm in the year 2000 (in thousand EEK)

		Sales/empl		VA/empl	VA/empl	TFP	TFP
Does the firm have Product Innovation	Does the firm have Process Innovation	Mean	95% Conf.Interval	Mean	95% Conf.Interval	Mean	95% Conf.Interval
No	No	546.65	461.10 631.90	136.63	125.62 147.63	37.68	34.65 40.71
No	Yes	549.09	383.41 714.77	197.57	125.04 270.11	40.3	31.12 49.46
Yes	No	576.11	427.89 724.44	158.63	132.17 185.09	48.14	39.34 56.94
Yes	Yes	684.56	569.63 799.49	185.03	157.72 212.34	56.39	46.84 65.93

Note: No. of obs. 2734; empl = average number of employees in the year, VA = value added.
Source: own calculations based on database of manufacturing and services sector enterprises from the Business Register of Estonia.

As can be observed the most productive firms tend to be those that have both product and process innovation. This finding holds for sales based labour productivity measures and for the TFP comparison on the basis of different groups of firms.

It may be that these differences in average productivities between these four different groups of firms result simply from some particular sector or region specific effects or, in the case of labour productivity, from different capital intensities between innovative firms and non-innovative firms. To account for that, I regressed the log of the firms' TFP (thus differences in capital intensity between firms have been taken into account in calculating the TFP in the first phase) on innovation dummies, control variables for sector competition/concentration (the Herfindahl index) and sector and region dummy variables (see Table 8). I include one dummy variable to indicate whether the firm had product innovations in period 1998–2000, another to indicate whether it had process innovations (in 1998–2000) and an interaction variable between these two. The interaction term enables to take a look at firms that have both types of innovation and to compare the differences in the TFP premium on the basis of different groups of firms as in the last table, but now in the context of

Table 8: Regression results for the year 2000, TFP premium and innovative activities of the firm

Dep. var. is log TFP	**Coef.**
Firm has product innovation	0.158***
	(0.056)
Firm has process innovation	0.132**
	(0.053)
Product innovation*process innovation	-0.05
	(0.086)
Herfindahl index (at 3-digit industry level)	-0.524**
	(0.231)
Observations	1821
R-squared	0.74

*Note: regression includes industry and location dummies and logarithm of the size of the firm. Heteroscedasticity robust standard errors are in parenthesis. ***, **, * denotes statistical significance at 1, 5 and 10 per cent level, respectively.*

a conditional mean analysis.

Indeed, I find that even when controlling for the sector or location specific effects[12] and competition in the sector, the innovative firms seem to have a higher TFP than the rest. That means that the rate of return on innovating is positive and significant, even after controlling for several other firm or sector specific variables. Firms that have only product innovations, have a TFP premium of 15.8 per cent if compared to those that have no innovations at all, firms that have process innovation only, have 13.2 per cent TFP premium and these firms that report both types of innovation have 28 per cent higher TFP level than the enterprises not reporting any innovative activities. The Herfindahl index accounting for competition related effects is significant and negative in this cross sectional regression for year 2000. This indicates that the increase in concentration in a (3-digit level) sector is in this year negatively related to the firm's productivity in that sector. I put the competition effects under closer examination in the following paragraphs based on a larger panel dataset, which has the benefits of including the time dimension and the large number of enterprises into the analysis, however, unfortunately does not include panel level information on the innovative activities of firms.

A different enterprise level dataset from the Estonian Statistical Office provides us with a limited look at the persistence of the innovative activities of firms. It has balance sheet and income statement data for about 326 firms over the period from 1995 to 2001. It also includes information about whether firms

[12] Also here in the conditional mean analysis, firms in Tallinn have on average higher TFP than the rest.

report R&D costs in the corresponding year. Naturally, I would have preferred to have had a time series of information not only on innovation input (i.e. R&D) but also for outputs, however this dataset has only information about R&D. I look at transitions among firms over these years between categories of firms, between groups that had some R&D expenditures and groups that had no R&D expenditures.

Table 9: Transition matrix between firms that spend on R&D and those that do not (1996–2001, percentages)

		Time *t+1*	
		No R&D	Has R&D
Time *t*	No R&D	92.6	7.4
	Has R&D	48	52

Source: own calculations based on ESA panel of firms (326 firms) during 1996-2001.

From this data it appears that firms not doing any R&D were not likely to start with it during that period. Only 7.4 per cent of non-R&D firms started to spend on R&D in the following year. In addition to that, the firms already spending on R&D are very likely not to continue with it in the next year (48 per cent drop this activity in the next year). Based on that, and provided we trust the data on reported R&D costs of firms[13], it seems that R&D spending has been relatively random among firms — persistence in this activity is very low. One might have perhaps expected that R&D spending has some sunk costs, thus forcing firms to continue with the activity in the following years in order to gain from it. The persistence of firms based on this database is much higher in the case of exporting and FDI, only 3.6 per cent of manufacturing firms that exported in a given year in the period 1996–2001, drop it in the following year. The persistence in terms of being a firm with inward FDI or outward FDI is very similar to those exporting.

One way to improve a firm's productivity, in addition to engaging in innovation activities of its own, is certainly via knowledge diffusion. Innovation may require considerable investments, imitation of that which is done elsewhere may require significantly less. However, even in the case of imitation, the higher absorptive capacity of the firm may be a decisive factor in benefiting from external knowledge (Cohen and Levinthal, 1989). Thus in order to benefit from external knowledge via imitation, the firm may need to invest in knowledge creating activities. The productive knowledge may have the characteristics of a public good, and thus all the benefits of innovating may not

[13]The data from the CIS type survey about innovations is more trustworthy, as information on R&D spending in this small panel may not always reflect the true expenditures on R&D.

always be reaped by the innovator itself, some of them may spill over in the form of positive externalities to other firms that have not spent on innovating; therefore lowering the benefits of innovating and incentives to innovate and raising the incentive to try sourcing the same information from outside the firm (Griliches, 1992).

Thus, imitation may be an important source of knowledge, and one may ask which of these dominates in the case of Estonia — innovation as a source of productivity improvements or imitation/knowledge diffusion? There are several studies addressing international knowledge transfer in Estonia. Knowledge transfer via FDI has been studied to a significant extent in Estonia (e.g. Varblane, 2001; Vahter and Masso, 2005; Sinani and Meyer, 2004), recent extensions (Varblane et al., 2001; Vahter and Masso, 2005) also include the analysis of the effects of becoming involved in outward FDI. Both inward and outward FDI have been found to be important contributors to the productivity of the firm itself by these studies. Vahter and Masso (2005) found that the TFP premium of the firm before receiving FDI and before becoming involved in outward FDI was significantly lower than the TFP premium after receiving or making FDI, thus indicating potentially positive causal effects of FDI. The results about FDI spillovers (i.e. externalities) are however not as positive — spillovers of FDI seem to be smaller than the direct effects on the subsidiary or the parent of the multinational enterprise and are very likely to be specific to the type of FDI or the type of subsidiary. These positive spillover effects are likely to increase in the future as the Estonian economy develops, and correspondingly the absorptive capacities of firms (needed for successfully implementing foreign knowledge) grow.

If we compare the unconditional or conditional productivity differences: 1) between firms that have FDI and those that have not, with 2) the differences in productivity between innovative and non-innovative firms, we see that, based on the findings from the Business Register database, the productivity premium for firms that have either received or made FDI is far larger than that for innovations (Vahter and Masso, 2005). However, a large part of this FDI premium is indeed due to the self-selection effect, due to the fact that more productive Estonian firms receive FDI or are themselves able to make outward FDI (Vahter and Masso, 2005). This self selection effect may, in fact, be at work in the case of the innovation premium as well — the most productive firms may possibly be able to spend more on research and development activities, thus the TFP premium of FDI is still likely to surpass that of innovation (based on the Innovation Survey 2000 data merged with the Business Register Database). Still, both knowledge transfer via FDI and innovation are important determinants of a firm's productivity. However, panel data covering information on innovation inputs and outputs over several different years could give more insight into the causal role of innovation in productivity upgrading in Estonia than the cross-section analysis.

Knowledge transfer via trade in Estonia has been addressed to a significantly lesser extent. One finding by Vahter (2005), from a small panel of manufacturing firms (326 per year, period 1996–2001), is that firms that export more than 50% of their sales had lower labour productivity than the firms producing predominantly for the domestic market. This finding, in fact, corresponds well to recent findings by Männik and von Tunzelmann (2005) that the high-tech (HT)[14] sectors had lower productivity than the other sectors in Estonia. In the case of Estonia, the export platform electronics sectors dominate the HT sector, they are often almost 100 per cent export oriented and often do not have high productivity on average.

In Table 8 I already started to look at competition effects by including the Herfindahl index to account for concentration effects in sectors defined at the 3-digit level. Next, I proceeded by estimating a model similar to Nickell (1996) and Okada (2005) based on the Estonian Business Register enterprise level data as outlined in Section 3 and Equation 7. The model is estimated in first differences in order to eliminate time invariant fixed effects.

The results on the role of competition effects in productivity dynamics are presented in Table 10 for the manufacturing industry and in Table 11 for the services sector. In the case of the manufacturing industry, we could also, in addition to other competition related variables, include the import and export penetration ratios at the 2-digit sector level. These are to account for the openness of the sector and the foreign competition.

The only variables that have significant coefficients are the first difference of the Herfindahl index ($\Delta CONC_{jt}$), in both manufacturing and services sectors, and in the case of the manufacturing industry also import penetration ($\Delta IMPORT_{jt}$). They both have negative coefficients. The coefficient of the Herfindahl index (at 3-digit level) indicates a negative association between the firm's productivity and an increase in the concentration of the sector. This might indicate a positive effect of a decrease in concentration and of a rise in competition[15]. However, note that the concentration and competition may not be the same. The relevant market may naturally not be the one defined in the NACE classification of sectors at 3 or 4-digit level. It could also be argued that this framework suffers from potential multi-collinearity among competition related variables. For that reason I also performed a regression analysis separately with each individual competition "measure" included. The coeffi-

[14] According to the standard OECD classification of sectors by their "technology intensity".

[15] However, for the analysis of causal effects of competition the GMM approach will be more useful.

Table 10: Productivity/competition relation in the manufacturing sector, estimated in first differences (dependent variable ΔTFP)

	Manufacturing					
	I	II	III	IV	V	VI
$\Delta MSHARE_{ijt-2}$	-0.0415	0.031			-0.1197	
	(0.1289)	(0.1586)			(0.1413)	
$\Delta LERNER_{ijt-2}$	-0.0002		-0.0002		-0.0002	
	(0.0003)		(0.0003)		(0.0003)	
$\Delta CONC_{jt}$	-0.7922***			-0.7457***	-0.5081***	
	(0.2275)			(0.1668)	(0.1811)	
$\Delta IMPORT_{jt}$					-0.3958***	-0.4205***
					(0.0459)	(0.0335)
ΔEXP_{jt}					-0.0829	
					(0.095)	
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6763	7256	6279	10152	6186	9359
R-squared	0.07	0.056	0.056	0.073	0.118	0.081

Source: own calculations based on panel data of Estonian firms 1995–2002.
*Note:. The robust t-statistics are in parentheses. ***, **, * denotes statistical significance at the 1, 5 and 10 per cent level, respectively.* $\Delta MSHARE_{ijt-2}$ *and* $\Delta CONC_{jt}$ *are calculated for 3–digit NACE level sectors.*

cients stay relatively similar to the case when all are included in one equation. The negative sign of the import penetration variable indicates a significant effect from foreign competition. The sector level export orientation variable has a negative sign, but is not significant. Based on former findings, it could indeed be expected that predominantly export oriented sectors may not always have the highest productivity in the case of Estonian data. In fact, the effect of export orientation need not be a linear one.

The findings that the Lerner index is not significant may also possibly indicate that the competition effects on productivity may not be linear. In order to test for that, I have also tried a different specification with the squared terms of each competition related variable included. The squared terms did not prove to be statistically significant, except in the case of the Lerner index (the most preferred measure of competition) in the manufacturing industry. When we included the squared term of the Lerner index in the regression for the manufacturing industry, the coefficient of the non-squared term proved to be negative and significant, the coefficient of the squared term was positive, but in its absolute value significantly smaller than that of non-squared variable. The total metric effect of an increase in the Lerner index (i.e. the market power) seemed to be small and negative and also different for different values of the Lerner index.

To sum up, I have provided some evidence, based on the present work and on some former studies, that both innovation and diffusion of knowledge are

Table 11: Productivity/competition relation in the services sector, estimated in first differences (dependent variable ΔTFP)

	Services			
	I	II	III	IV
$\Delta MSHARE_{ijt-2}$	0.462 (0.4392)	0.4759 (0.4275)		
$\Delta LERNER_{ijt-2}$	0.0014 (0.001)		0.0013 (0.0011)	
$\Delta CONC_{jt}$	-1.005*** (0.2317)			-0.8589*** (0.181)
Year dummies	Yes	Yes	Yes	Yes
Observations	21421	25950	21421	33793
R-squared	0.10	0.05	0.034	0.086

Source: own calculations based on panel data of Estonian firms 1995–2002.
*Note:. The robust t-statistics are in parentheses. ***, **, * denotes statistical significance at the 1, 5 and 10 per cent level, respectively. $\Delta MSHARE_{ijt-2}$ and $\Delta CONC_{jt}$ are calculated for 3 – digit NACE level sectors.*

important determinants of productivity for firms in Estonia. Based on a relatively traditional framework (with additions to account for non-linear effects), relatively similar to Nickell (1996) or Okada (2005), I have found some indication of the positive effect of an increase in competition on the productivity of the firm. However, the present analysis also indicates the limits of addressing the competition effects in such an environment as it excludes the dynamic side of competition (i.e. the entry and exit of firms, this topic has been partly covered in a recent paper by Masso et al., 2004) or the potential competition (the threat of entry of other firms as measures of competition). For more definite conclusions about the effect of competition on productivity, the potential competition effects should be analysed in future.

7. Conclusions

In this paper I have described the productivity differences between firms in Estonia and their determinants based on enterprise level panel data of the population of Estonian firms. I have addressed, based on my own analysis and some earlier papers, the importance of selected factors of productivity differences and growth, such as innovation, knowledge diffusion and to some extent also the product market competition. Advantages of the paper are that, in addition to the manufacturing industry, I can analyse productivity in the services sector, and I used methods that account for the endogeneity of inputs in the regression analysis.

I have estimated the total factor productivity of firms with the Levin- sohn-

Petrin (2003) semi-parametric procedure that controls for the endogeneity of inputs. The results of estimating TFP with this method do indicate that the endogeneity bias of the OLS or FE model is substantial in the case of Estonian data. Thus, other methods for estimating the TFP may lead to biased estimates of the coefficients of inputs and accordingly then to biased inferences about the TFP and the role of different factors that affect the TFP of firms.

I find a huge variation in terms of different productivity indicators among Estonian firms. The productivity spread in Estonia is much larger than in, for example, the UK or in other Western European countries. Only a small part of this variation can be attributed to the differences in sector specific (and in the case of labour productivity to capital intensity of the firm) or region specific characteristics (e.g. firms in Tallinn have significantly higher productivity than firms elsewhere). Thus, something similar to the well-known Mandelbrot's fractals phenomenon seems to be at work here, the lower level of the aggregation of sectors does not necessarily always have much lower variation in terms of the productivity of the firms (see also Griliches and Mairesse, 1995). The use of thinner slices of data does not bring about a large decline in the observed heterogeneity of firms.

The existence of both good spread (due to the entry of high productivity firms and the exit of low productivity firms in Estonia, as indicated in Masso et al., 2004) and bad spread (binding resources in low productivity surviving firms that tend not to upgrade in productivity distribution) both underline the importance of competition and the need to upgrade the laggard firms (or ensure the exit of the least efficient firms) in order to sustain productivity growth in Estonia. As the findings for other countries also imply, the productivity spreads can be a potential source of aggregate productivity improvement. This potential stresses the importance of entrepreneurship support programs that target the laggard firms that have some potential for upgrading and at the same time shows the need for keeping the exiting barriers low in order not to hinder the movement of labour and resources from low productivity firms to higher added value creating activities.

Based on my own analysis and some other earlier studies I find that both innovation and knowledge diffusion play a significant role as determinants of productivity, both in the manufacturing and the services sector. The diffusion effects seem to have been outnumbering the effects of innovation (possibly due to general low innovative activities of firms).

The role of competition is more controversial — it seems that to some extent the increase in local product market competition is positively related to the TFP of firms in the sector. Still, the Nickell (1996) style method that was used here has its disadvantages, as it does not include the dynamic (entry and exit of firms) and potential (threat of entry) competition into the analysis. The next step in the analysis of the effects of competition based on Estonian data will also include the system-GMM approach and stochastic frontier analysis of productivity (instead of the restrictive Cobb-Douglas framework).

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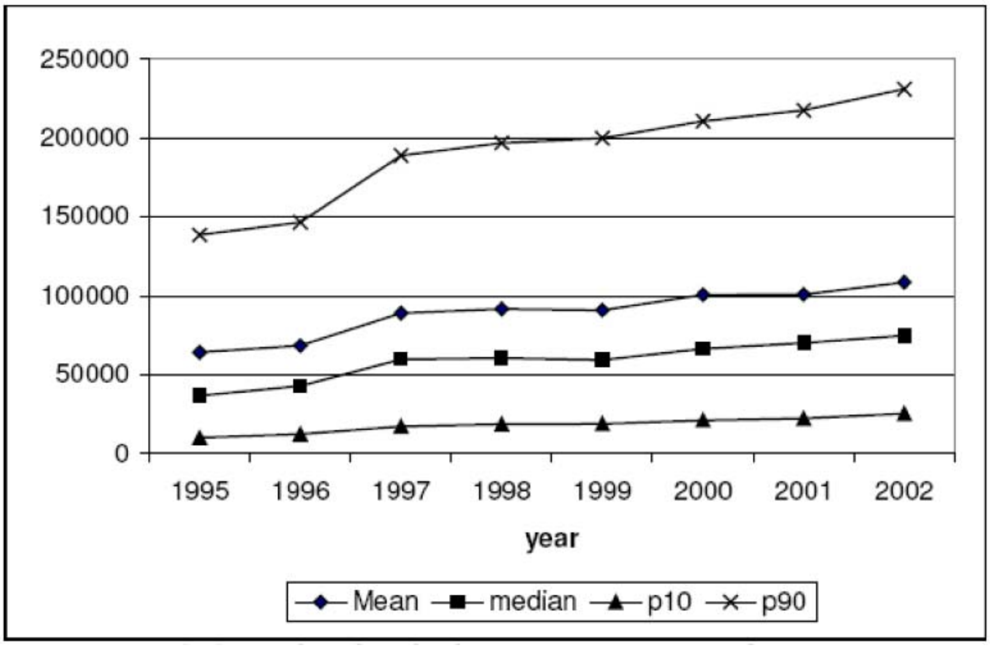
Appendix 1. Descriptive statistics from the Business Register database (labour productivity indicators)

VA/empl	EEK, in 1995 prices	
Manufacturing	**1995**	**2002**
Mean	64182	108477
st. error	2522	2075
median	36727	74619
p10	10030	25232
p90	138677	231105
p90/p10	13.83	9.16

VA/empl	EEK, in 1995 prices	
Services	**1995**	**2002**
Mean	78174	121636
st. error	1708	1214
median	38152	76590
p10	9001	19698
p90	192426	285050
p90/p10	21.38	14.47

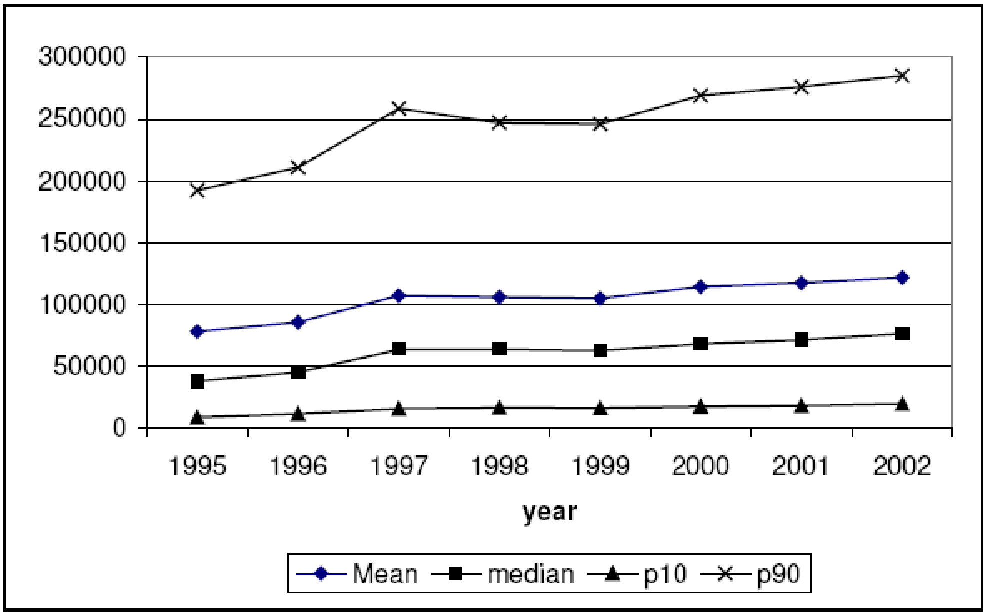
Note: p10 – lowest decile, p90 highest decile; VA – value added, empl – average number of employees in a year.
Source: own calculations based on database of manufacturing and services sector enterprises from the Business Register of Estonia.

Appendix 2. Descriptive statistics — dynamics of the unweighted average of value added per employee in in manufacturing (in EEK)



Source: own calculations based on database of manufacturing and services sector enterprises from the Business Register of Estonia.

Appendix 3. Descriptive statistics — dynamics of the unweighted average of value added per employee in services sector (in EEK)



Source: own calculations based on database of manufacturing and services sector enterprises from the Business Register of Estonia.

Appendix 4. Labour productivity (sales/employees) transition matrix, manufacturing sector (1995–2002, percentages)

Quintiles	Lowest	2nd	3rd	4th	Highest	Total
Lowest	58.7%	16.0%	9.3%	12.0%	4.0%	100.0%
2nd	33.9%	42.2%	16.5%	4.6%	2.8%	100.0%
3rd	13.9%	31.3%	29.6%	18.3%	7.0%	100.0%
4th	3.9%	15.5%	33.3%	36.4%	10.9%	100.0%
Highest	2.4%	4.7%	11.0%	22.1%	59.8%	100.0%

Source: own calculations based on database of manufacturing and services sector enterprises from the Business Register of Estonia.

Appendix 5. Labour productivity (sales/employees) transition matrix, services sector (1995–2002, percentages)

Quintiles	Lowest	2nd	3rd	4th	Highest	Total
Lowest	55.5%	24.3%	13.0%	4.5%	2.8%	100.0%
2nd	31.7%	32.9%	18.0%	13.4%	4.0%	100.0%
3rd	11.1%	26.9%	30.5%	23.6%	8.0%	100.0%
4th	8.3%	13.0%	26.9%	34.7%	17.2%	100.0%
Highest	2.8%	4.5%	10.0%	25.2%	57.5%	100.0%

Source: own calculations based on database of manufacturing and services sector enterprises from the Business Register of Estonia.

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