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# FIRM PRODUCTIVITY: the Role of Competition and of the Initial Firm Efficiency. Evidence from the Czech Republic.

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# Firm Productivity: the Role of Competition and of the Initial Firm Efficiency. Evidence from the Czech Republic[°]

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*Abstract:* It has been argued that the effect of competition on a company's incentive to innovate and to reduce managerial slack depends on the initial level of efficiency. For example, while firms close to the technology frontier invest more in innovation if competition increases, backward firms reduce innovation. On a panel data of Czech companies, for the years 1993-2005, we empirically assess the impact of increased competition on firm productivity and the importance of the initial firm efficiency level. We depart from the empirical literature on emerging markets by taking into account both domestic and foreign competition. In line with the theory, our results show that there is an inverted U-relationship between domestic competition and firm productivity. Our results also confirm that trade liberalization has a positive impact on productivity. However, the effect is less significant if domestic competition is not taken into account. In addition, we find that both domestic and foreign competition have an effect on productivity in companies close to the technology frontier but not in backward companies.

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## 1. Introduction

After the collapse of the communist regimes in 1989 in Central and Eastern Europe, the countries in the region opened up their economies to foreign trade and foreign direct investment (FDI), and introduced reforms to encourage domestic competition. Among other benefits, reforms that promote competition have been expected to lead to higher productivity. The bulk of theoretical and empirical research backs up this view, pointing for example to the disciplinant effect of competition and to benefits steaming from improved access to intermediate goods (Romer 1994). Yet, there are also theoretical arguments which suggest that in certain circumstances increased competition has a negative impact on productivity. For example, in industries characterized by increasing returns to scale, increased competition might force domestic firms to scale down production and hence to move to higher average costs. In addition, competition might decrease the expected gains from innovation, and thus the innovation level, in companies that are far away from the technology frontier as these companies expect to loose market share to more efficient entrants (Boone 2000 and Aghion et al 2005b). Also an increase in competition might exacerbate the managerial slack problem if managers are highly responsive to monetary incentives (Scharfstein 1988). The slack problem also worsens if owners' benefits from a marginal increase in efficiency decrease with the number of competitors as could be the case in Cournot competition (Martin 1993).

All these theoretical results seem to indicate that the actual impact of increased competition on firm productivity dynamics might be ambiguous and, furthermore, that it might be context dependent. Whether the context plays a role in determining the actual impact of increased competition on firm productivity is an empirical question. Results emerging from the empirical literature emphasize the role played by policies and institutional aspects (see Winters 2004 for a survey). Less studied is the contribution that the industrial context has to this impact. In particular, the fact that the initial firm efficiency level affects innovation and therefore the firm productivity in a context of increased competition (Boone 2000, and Aghion et al 2005b) has been addressed by few empirical studies (Bernard et al 2006, and Konings and Vandenbussche 2007). The studies that have addressed this issue focused on the impact of a specific reform – trade liberalization – on firm productivity and the role played by the firm efficiency level. However, especially in emerging economies, trade reforms that promote openness are typically accompanied by other reforms that promote competition in general. Therefore, to assess the overall impact on competition on firm productivity one has to consider both domestic and import competition. In addition, if other reforms are not taken into account one might attribute too much of changes in productivity to foreign competition.

This paper analyzes the impact of competition on firm productivity, with a special focus on the degree by which the initial firm efficiency affects the relation between increased competition, on the one hand, and firm productivity, on the other hand. The analysis is done using a panel data of Czech firms for the period 1993-2005. In the Czech Republic's transition process, fast and comprehensive trade and FDI liberalization has been accompanied by other reforms that have spurred competition (e.g. the reform of the financial system, the introduction of bankruptcy laws). As already indicated, we depart from the empirical literature on emerging markets by taking into account both domestic and foreign competition.

We find that trade liberalization has a positive impact on firm productivity. Yet, this effect weakens with the increase in the initial level of tariff protection. Our results also show that an increase in market concentration induces higher productivity in markets in which domestic competition is tough. The latter result is consistent with the theoretical literature that suggests that both innovation and managerial efficiency lead to an inverted U-shape relationship between productivity and competition.

With respect to the role of the initial level of cost efficiency for the impact of competition on firm productivity, we find that the above results regarding the impact of competition, both domestic and foreign, are not present in companies that are far away from the technological frontier, where there is practically no effect of competition on firm productivity. Furthermore, we assessed the extent to which the absence of a control for domestic competition biases the estimated effect of trade liberalization on firm productivity. We find that the effect of trade liberalization on firm productivity is seriously understated if a control for domestic competition is absent. Moreover, the fact that the initial firm efficiency affects the impact of trade liberalization is not anymore fully confirmed in these regressions. Thus, our results indicate that to assess the extent to which trade liberalization affects firm productivity one needs to control for domestic competition and to take into account the initial firm efficiency levels.

The paper proceeds in the following way. Section 2 reviews the theoretical research that links competition and firm productivity and the existent empirical work. Section 3 describes the data we use and the methodology on which we base our empirical analysis. Section 4 presents the empirical results and the results of several robustness checks. Section 5 concludes.

## 2. Competition and productivity. Theory and empirical results.

That increased competition in general has an effect on firm performance is already well established in the theoretical literature, though the sign of this effect might be ambiguous.[1]

One of the perceived benefits from increased competition stem from the effect competition has on managerial slack. In companies in which managers have more information than owners about productivity shocks and own effort, if monopoly rents exist, managers can capture part of them in the form of slack. Yet, faced with higher competition, managers have to increase their effort to fulfil targets specified by incentive schemes (Hart 1983, and Scharfstein 1988). In addition, since unobserved productivity shocks are likely to be correlated across firms, higher competition from more efficient companies increases owners' opportunities to compare or to assess the actual performance of their companies, and thus to design sharper incentive schemes (Nalebuff and Stiglitz 1983, Hermalin 1992, Holmstrom 1982, Meyer and Vickers 1995, and Nickell 1994). However, designing incentive schemes that induce high performance might become too costly when competition is strong as the additional effort necessary to deliver a good rather than a bad performance increases with competition, hence increasing managers' incentives to underreport their productivity. Therefore, the effect competition has on slack might be non-linear, of a U-shape (Scharfstein 1988, Hermalin's 1992, Meyer and Vickers's 1997, among others). The fact that competition might have a U-shape relation with managerial slack has been backed up by Schmidt (1997), who showed that competition not only raises the probability of liquidation, but also reduces profits. Therefore when competition becomes too intense, managerial effort might in fact decrease with further increase in competition.

Another benefit from increased competition steams from its effect on innovation, as a monopolist tends to "rest on his laurels" (Arrow 1962) or might get trapped in bureaucratic structures (Schumpeter 1934). Yet, Schumpeter (1942) has noticed that most of the innovation is done in big firms that have the necessary resources to invest and are able to accrue the associated benefits due to their position in the market. Therefore, much as the impact of competition on effort, the effect of competition on innovation could have an inverted U-

[1] For instance, see Winters (2004) for the impact of openness on firm performance. Also see Djankov and Murrell (2002) for a survey of literature for transition economies.

shape.[2]

There is also an emerging literature on the role played by the initial level of firm efficiency in defining the actual impact of competition on firm productivity (Aghion et al 2005b, and Boone 2000). Thus, the threat of entry encourages incumbent advanced firms to invest in innovation in order to retain their market but discourages innovation in firms far from frontier as those companies expect, under any circumstances, to loose markets to more efficient entrants (Aghion et al 2005b, and Boone 2000). These results suggest that the relationship between competition and innovation (thus, firm productivity) is influenced by the initial firm productivity.

To sum-up, theoretical results indicate that the relation between competition and firm productivity might have an inverted U-shape (either due to the U-shape relationship between competition and managerial slack and/or due to the inverted U-relationship between competition and innovation). Furthermore, the above results suggest that this relationship might be different in firms that are close to the technology frontier than in backward firms.

Turning to the empirical literature, several empirical results support the theoretical conjecture of a U-shape impact of competition on managerial slack (Green and Mayes 1991) and of an inverted U-shape relationship between innovation and competition (Scherer 1967, and Aghion et al 2005a). In addition, the empirical literature has often addressed these relations indirectly, by searching for a relation, usually linear, between competition and firm productivity. Thus Nickell et al (1992) and Nickell (1996) found that an increase in import competition had no impact on firm productivity in UK manufacturing. Yet, an increase in market share had a negative effect on the level of productivity, probably due to the negative effect that an increased in monopoly power has on managerial and workers' effort.

More generally, decreases in trade costs also spur competition, and to that account there are numerous papers that look at the effect of openness on productivity. Substantial evidences show that changes in openness lead to a reallocation of resources and market shares from inefficient to efficient firms, and therefore had a positive impact on the evolution of industry productivity (for a review see Tybout 2003). There are also evidences that trade cost

[2] Aghion et al (2005a)'s theoretical model confirms this fact.

reductions enhance productivity at the plant level both in developing and developed countries (see Pavcnik's 2002, Bessonova et al 2003, or Sabirianova et al 2005a for studies on emerging economies, and Lawrence 2000 and Bernard et al 2006b for studies on the US).

Thus, apparently, empirical analyses that consider only one aspect of competition – trade cost reductions – yield different conclusions regarding the impact of trade liberalization on productivity than those papers that consider both foreign and domestic competition. As indicated by the theoretical results, this might be due to differences in the context in which trade liberalization has taken place (e.g. the initial level of firm efficiency in the industry) but could also be due to the fact that in the absence of a control for changes in domestic competition induced by other market reforms that typically (although not always) accompany trade reforms, the coefficient of trade liberalization picks up their effects. This is one aspect that we investigate in our empirical analysis.

As the impact of competition on firm productivity seems to be contextual dependent, several studies have tried to unveil the underlying conditions that favour a positive relation between increased competition and firm productivity. Emerging results emphasize the role played by policies and institutional aspects (see Winters 2004 for a survey) or by industrial aspects. Among the studies that have focused on the latter factors, results show that a positive and a stronger relationship between competition and firm productivity is likely to exist in highly concentrated industries (MacDonald's 1994), in low-skill intensive industries (Lawrence 2000), or in non-multinational companies (Bernard et al 2006).

Also, some empirical studies address the role the initial efficiency level plays in moderating the impact of competition on firm productivity, as suggested by the theoretical studies of Boone (2000) and Aghion et al (2005b). Aghion et al (2005b) show that entry liberalization lead to a rising inequality in the regulated manufacturing sector in India, and moreover, that productivity increased by more in industries that were close to the Indian productivity frontier. Sabirianova et al (2005) find that increased foreign presence in Czech and Russian industries lead to a rise in the efficiency of foreign firms, which are assumed to be at the outset closer to the technological frontier, but had a negative effect on productive efficiency of domestic firms, which are less efficient. Konings and Vandenbussche (2007) find that a decrease in competition due to antidumping protection helps more laggard EU companies than cost efficient ones. Topalova (2004)'s results, however, show that trade liberalization did not lead to divergence in productivity within Indian industries as similar productivity improvements can be noticed in firms with both high and low productivity prior to the trade reform. As well, Bernard et al (2006) find no evidence that the impact of trade costs reduction on productivity was different for firms with different productivities in US manufacturing. Thus, there are few but mixed evidences of a differential impact of competition on firm productivity according to the initial efficiency level.

The present study analyzes the impact of competition on firm productivity, and compares the response to competition of firms that are closer with those that are farther away from the technological frontier. Among the studies we have mentioned above, only three directly tackle the discrepancy in response to competition of *firms* with different initial efficiency: Bernard et al's (2006), Topalova (2004), and Konings and Vandenbussche (2007). These papers, however, look only at the effect of trade cost reductions on firm productivity. Given the inferences we drawn from Nickell et al (1992) and Nickell's (1996) results, unlike these studies, we look at the impact of both domestic and outside competition on firm productivity. This allows us to assess in this study the extent to which the absence of a control for domestic competition biases the effect of trade liberalization on firm productivity and the conjectures regarding the differing impact of trade liberalization on productivity with respect to the initial firm efficiency.

## 3. The empirical methodology and data description

### *3.1. Methodology*

We do our empirical analysis in two steps. First, we estimate firm productivity. Second, we study the impact of competition both on all firms and on sub-samples that have at the outset high/low productivity.

#### *3.1.1. Estimating firm productivity*

We assume a Cobb-Douglas production function

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \omega_{it} + \upsilon_{it} \qquad (1)$$

where $i$ is the firm index, $t$ is the time index, $y$ is log of output, $k$ is log of capital, $l$ is log of labour, and the residual term is decomposed into a time varying productivity shock, $\omega$, that is not observed to the econometrician, and a white noise, $\upsilon$. To estimate this production function we use the semiparametric approach developed by Olley and Pakes (1996) that allows us to obtain a time-varying measure of plant productivity that accounts for the simultaneity bias. If firms that experience a positive shock known only to the firm choose to use more of the variable inputs, the OLS estimates of the production function will be biased upwards.[3] [4]

Estimators of (1) that take into account the simultaneity bias could be obtained in two steps. In a first step the investment, *i*, which is a function on the extant capital and firm productivity is inverted to express unobserved productivity, $\omega$, as a function of observables: $\omega_{it} = h(i_{it}, k_{it})$.[5] This implicitly assumes that investment increases with productivity and that investment levels are strictly positive. Then the following equation is estimated

$$y_{it} = \beta_l l_{it} + \left(\beta_0 + \beta_k k_{it} + h(i_{it}, k_{it})\right) + \upsilon_{it} \tag{2}$$

to get consistent estimates of $\beta_l$. Next, we consider the expectation at time *t*-1

$$E\left[y_{it} - \beta_l l_{it} \middle| k_{it}\right] = \beta_0 + \beta_k k_{it} + E\left[\omega_{it} \middle| \omega_{it-1}\right]$$

which, given that productivity follows a first order Markov process (which is assumed in the OP procedure) leads to

$$y_{it} - \beta_l l_{it} = \beta_k k_{it} + \theta(\phi_{it-1} - \beta_k k_{it-1}) + \xi_{it} + \upsilon_{it} \tag{3}$$

and thus to consistent estimates of the capital coefficient ($\xi$ stands for unexpected productivity shocks). Equations (2) and (3) are estimated using polynomial expansions for *h*() and $\theta$().

Firm productivity is calculated as

$$pr_{it} = y_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it} \tag{4}$$

for each industry.[6] We further define a productivity index as being the difference between a firm's productivity and the average productivity in the industry (at 2-digit level) in the year 2000,

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[3] In addition to the simultaneity bias, the OLS estimates of the above production function are likely to be plagued by a self-selection bias that is connected to firm entry and exit. With respect to exit, firms with more capital are likely to sustain higher adverse shocks without exiting. The Olley and Pakes (1996) procedure allows one to control for the self-selection bias associated with firm exit which induces a downward bias in the estimates of the capital coefficient. We cannot, however, control for this bias since in our sample there are too few firms that exit the market.

[4] Alternatively, we could use the GMM estimator developed by Blundell and Bond (1998). Yet GMM estimates produce small and insignificant capital elasticities and sharp decreasing returns to scale due to the fact that the series on sales, capital and employment are highly persistent so lagged levels are only weakly correlated with subsequent first differences (Blundell and Bond 2000 and our own estimations).

[5] See Good, Nadiri and Sickles (1996) for a discussion of the properties that various productivity indexes have (this one is transitive and insensitve to the units of measurement).

[6] Levinsohn and Petrin (2003) (LP) has further modified the OP procedure by using intermediate inputs instead of investment to control for unobservables. Yet, unlike OP, LP need to assume perfect competition in the output market in order for the intermediate input to be monotonic increasing in productivity, and thus, to be able to invert the productivity shocks. In addition, Ackerberg et al (2005) argue that LP procedure suffers from multicollinearity that affects the estimate of the labor coefficient.

$$pi_{it} = pr_{it} - pr_I .$$

*3.1.2. The effect of competition on firm productivity*

Having estimated the productivity of the firm, we can now assess the effect of competition on firm productivity, by estimating the following model

$$pi_{it} = \alpha_0 + \alpha_1 c_{it-1} + \alpha_2 c_{it-1}{}^2 + \alpha_3 time_t + \alpha_4 ind_{it} + v_{it} \quad (5)$$

on the pooled data, where *c* is a vector of measures that aims to capture both domestic and foreign competition; *time* is a vector of year indicators that covers omitted macroeconomic events that affect all firms; $ind_{it}$ is the industry affiliation (at 2-digit level) and controls for unobserved industry-specific factors influencing the level of firm productivity; and $v_{it}$ captures all other shocks to firm productivity. To avoid possible endogeneity problems and to account for the fact that firms' adjustments to changes in competition may take time to materialize, we use lagged values of competition. We introduced a square term for competition to capture the fact that there might be a non-linear relationship between competition and firm productivity. As mentioned above, theoretical work has shown that there are at least two reasons why such a non-linear relationship might exist. First, between product market competition and innovation there is an inverted U relationship (Aghion et al 2005a). Second, there might be a U-shaped relation between competition and managerial slack (Schmidt 1997).

We first estimate the effect that competition has had on all firms in our data. Next, to see if firms that were closer to the technological frontier have reacted differently to changes in the level of competition than those that were farther away, we define a measure of firm inefficiency, *d*, which is interacted with competition, and we estimate the following equation

$$pi_{it} = \alpha_0 + \theta_1 d_{it-1} + \alpha_1 c_{it-1} + \alpha_2 c_{it-1}{}^2 + \theta_2 c_{it-1} d_{it-1} + \theta_3 c_{it-1}{}^2 d_{it-1} + \alpha_3 time_t + \alpha_4 ind_{it} + v_{it} \quad (6)$$

The inefficiency level, *d*, is defined as the difference between the productivity of the most productive company in the industry in the current year and firm's productivity, divided by the difference between the productivities of the most and the least productive firms. Thus *d* has values between 0 and 1, with the most efficient firm having *d* equal 0 and the least efficient one having *d* equal with 1. If competition stimulates frontier firms while hurting laggards, then $\theta_1$ and $\theta_2$ ought to have opposite signs to $\alpha_1$ and $\alpha_2$, respectively.

To further investigate the differential impact of competition on firm productivity with respect to the initial firm inefficiency we define laggards and frontier companies based on *d*, and we estimate (5) for each category. We consider companies with *d*s higher than 0.8 as laggards. Frontier firms, are defined as firms with *d*s lower than 0.2.

In order to check the robustness of our results we estimate (5) using firm productivity based on OP but also based on OLS results. In addition, it is known that measurement errors bias the coefficients toward zero. Neither OP nor OLS take this bias into account. One way to deal with this bias is to introduce a constant return to scale restriction in the estimates. We believe that the coefficient of capital is mostly affected by measurement errors. We assume that OP provides an unbiased estimate of the labour coefficient and we calculate the capital coefficient by subtracting from 1 the labour coefficient. We name the productivity computed in this way CRS_OP productivity.

*3.2. Data description*

The empirical analysis is done on a panel data set of Czech firms for the period 1993-2005. Unlike other former communist countries from the Central Europe, economic reforms have started in Czech Republic only after the collapse of the communist regime in 1989. Since then, the Czech economy has undergone extensive transformations and reforms that have encouraged both domestic and foreign competition: liberalization of prices, exchange rates, trade and FDI flows, decentralization of wage setting, drastic cuts in public subsidies to enterprises, and adoption of legislation on competition, corporate governance, and intellectual property rights. The main economic reforms are summarized in Table 1.

Firm level data is provided by Amadeus (see Appendix 1). We used data from all versions of the Amadeus database since 1996. The Amadeus database contains information on medium and large firms, including sector classification, balance sheets, profit and loss accounts, and the number of employees. We got an unbalanced panel of 5338 companies for the period 1993-2005. The number of companies that we have for each year varies from 366 in the year 1993 till 2954 in 2003. Figures A1.1, A1.2, A1.3 in Appendix 1 show that the average size (computed based on added value, capital, or employment) of the companies in our sample tends to decrease over time. The major changes occur in 1999 and 2000, the years immediately after the financial crisis that hit the Czech Republic in 1998.

Table 1. Main economic reforms

| *Timing* | *Reforms* |
|---|---|
| July 1990 | Cancellation of the negative turnover tax in Czechoslovakia |
| October 1990 – January 1991 | Cumulative devaluation of the koruna by around 75% against convertible currencies |
| January 1991 | A package of macroeconomic measures was launched. It included:<br>▪ price liberalization (except for some sensitive prices such as electricity, gas, heating, rents, postage, public transport, etc.)<br>▪ trade liberalization<br>▪ wage regulation<br>▪ drastic cuts in subsidies to enterprises<br>▪ restrictive monetary and fiscal policies<br>▪ sharp devaluation and the introduction of partial convertibility of the currency, koruna |
| December 16, 1991 | The Association Agreement with the EU was signed |
| January 1, 1993 | Dissolution of the Czech and Slovak Federal Republic |
| January 1993 | Introduction of VAT. |
| February 8, 1993 | Separate Czech and Slovak currencies were introduced |
| May 1993 | The first wave of voucher privatisation |
| May and July 1994 | Liberalization of coal and gasoline prices |
| March 1995 | The second wave of voucher privatisation |
| July 1995 | Abolition of general wage regulation |
| October 1995 | Full current account convertibility of the Czech koruna |
| January 1996 | Official application for EU membership |
| May 1, 2004 | The country becomes a member of the EU |
| January 2002 – December 2005 | Gradual liberalization of electricity prices |
| March 2003 – … | Liberalization of rents |
| January 2005 – December 2006 | Gradual liberalization of gas prices |

To this data we added information on firm entry and exit provided by the Czech Statistical Office (CSO) and detailed industry level data, such as producer price indexes, the price index of capital inputs, industrial output, tariffs, and imports. Details of sources, definitions of variables, and the data cleaning process, and descriptive statistics can be found in Appendix 1. Here we describe only our competition measure, *c*.

To capture effects arising from domestic competition we use, alternatively, two measure of market concentration at 4-digit ISIC level: *Herfindal* which is the Herfindal index and which is our main measure of domestic competition and *Mkt concentration* which is the concentration ratio and is used for robustness checks.[7] Both of them are computed based on the four largest firms in an industry. We use our own dataset to identify these companies. The sum of the squares of these firms' sales for *Herfindal*, or just the simple sum for *Mkt concentration* were normalized using the sum of the industrial output and imports. Both *Herfindal* and *Mkt concentration* are inverse measures of competition. To capture the effect of foreign competition, we use *Tariff rate*, a weighted average (by trade value) of effectively applied rates, at 4-digit ISIC level.

Due to the fact that we have data at the industry level only for the years 1995-2003, when estimating (5) and (6) we get an unbalanced panel of 7158 observations and 2249 companies for the period 1996-2004.

Table 2. Herfindal index by industry

| Industry | 1995 | 1999 | 2003 |
|---|---|---|---|
| 15 | 0.00469 | 0.00686 | 0.00791 |
| 17 | 0.02238 | 0.00725 | 0.00921 |
| 18 | | 0.00251 | 0.00171 |
| 19 | 0.00735 | 0.00439 | 0.00268 |
| 20 | 0.02053 | 0.01972 | 0.00656 |
| 21 | 0.03847 | 0.01164 | 0.02047 |
| 24 | 0.01712 | 0.02520 | 0.01366 |
| 25 | 0.00103 | 0.00027 | 0.00086 |
| 26 | 0.01803 | 0.01524 | 0.00984 |
| 27 | 0.01006 | 0.00279 | 0.00145 |
| 28 | 0.00350 | 0.00248 | 0.00294 |
| 29 | 0.00258 | 0.01010 | 0.00258 |
| 30 | 0.00006 | 0.00112 | 0.00000 |
| 31 | 0.02259 | 0.01049 | 0.00980 |
| 32 | 0.00507 | 0.00196 | 0.00079 |
| 33 | 0.00275 | 0.00728 | 0.00375 |
| 34 | 0.00961 | 0.00664 | 0.00703 |
| 35 | 0.03625 | 0.00603 | 0.02437 |
| 36 | 0.00821 | 0.00983 | 0.00285 |

Industries: 15-Food products and beverages; 17-Textiles; 18-Wearing apparel; 19-Leather manufacturing; 20-Wood and wood and cork products, except furniture; 21-Pulp, paper and paper products; 22-Publishing and printing; 24-Chemicals and chemical products; 25-Rubber and plastic products; 26-Non-metallic mineral products; 27-Basic metals; 28-Fabricated metal products, except machinery and equipment; 29-Machinery and equipment n.e.c.; 31-Electrical machinery and apparatus n.e.c.; 32-Radio, television and communication equipment and apparatus; 33-Medical, precision and optical instruments; 34-Motor vehicles, trailers; 35-Other transport equipment; 36-Furniture; manufacturing n.e.c.

[7] To obtain firm level real output we deflate value added with industry price index. Therefore changes in our measure of real output could be driven by changes in productivity as well as by changes in the price index, and our measures of market concentration capture, besides the effect of competition of firm productivity the positive effect that an increase in the market concentration has on price markups (see Amiti and Konings 2007).

In subsamples we have 725 (1096) observations in the low (high) productivity group and 158 (211) companies.

Data that we have on *Tariff rate* indicate that during the period we analyze, tariffs in Czech Republic have gradually decreased in almost all industries (see Figure A1.4). Also, our data indicates that from 1995 until 2003 there have been significant changes in the market structure (see Table 2). In most of the markets the competition has increased over the years.

**4. Results**

The OLS estimates of the production function (1) by industry at 2-digit NACE are reported in Table 3. To get the OP estimates of (1), we have estimated equations (2) and (3) for each industry separately, using polynomial expansions for $h()$ and $\theta()$ (of third, respectively fifth degree). These results are also given in Table 3. According to our previous discussions, if OP corrects for the simultaneity bias induced by unobservable firm characteristics, we would expect coefficients of employment smaller than the ones we have with OLS. In 3 cases out of 21, the estimated coefficients of employment do not decrease: industries 19 (manufacturing of leather), 21 (manufacturing of pulp and paper), and 35 (manufacturing of other transport equipment). The fact that the labour coefficient increases could reflect a negative correlation between the productivity shock and the use of labour in two of the industries. Overall these results indicate that the OP procedure corrects for the simultaneity bias.

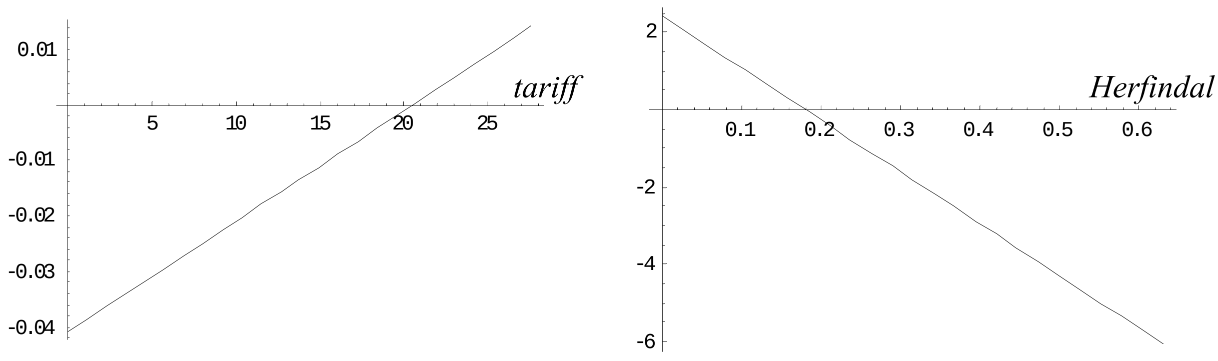
Turning to the effect of competition on firm productivity, our estimates of the equation (5) on all companies are given in Table 4, column (1). They show that Czech firms have benefited from trade liberalization, although at a decreasing rate. Evaluated at the sample mean (see Table A1.3 in Appendix), the marginal effect of an increase in tariff on firm productivity is negative – more import competition leads to higher productivity – and we stay with this effect even if we add two times the standard deviation (see Figure 1, (a)). Yet there are also few examples of the opposite effects as well, mostly in the food and beverages sectors (ISIC 1500) or for manufacturing of made-up textile articles (ISIC 1740) where the tariffs have been higher than in the rest of the industries.

Table 3. OLS and Olley and Pakes estimates of production function

| | OLS | | | | | Olley and Pakes | | |
|---|---|---|---|---|---|---|---|---|
| Ind. | Log Empl. | Log Capital | Returns to scale | No. Obs. | $R^2$ | Log Empl. | Log Capital | Returns to Scale |
| 15 | 0.547*** | 0.428*** | 0.975 | 2837 | 0.75 | 0.501*** | 0.510*** | 1.011 |
| 17 | 0.639*** | 0.290*** | 0.929 | 832 | 0.83 | 0.562*** | 0.230*** | 0.792 |
| 18 | 0.705*** | 0.203*** | 0.908 | 267 | 0.87 | 0.687*** | 0.261*** | 0.948 |
| 19 | 0.693*** | 0.196*** | 0.889 | 156 | 0.79 | 0.729*** | 0.204*** | 0.933 |
| 20 | 0.617*** | 0.355*** | 0.972 | 654 | 0.79 | 0.564*** | 0.207*** | 0.771 |
| 21 | 0.446*** | 0.486*** | 0.932 | 315 | 0.81 | 0.448*** | 0.201*** | 0.649 |
| 22 | 0.546*** | 0.282*** | 0.828 | 525 | 0.73 | 0.518*** | 0.158*** | 0.676 |
| 24 | 0.523*** | 0.420*** | 0.943 | 786 | 0.84 | 0.457*** | 0.377*** | 0.834 |
| 25 | 0.538*** | 0.379*** | 0.917 | 1123 | 0.84 | 0.499*** | 0.390*** | 0.889 |
| 26 | 0.500*** | 0.466*** | 0.966 | 1294 | 0.81 | 0.487*** | 0.292*** | 0.779 |
| 27 | 0.617*** | 0.327*** | 0.944 | 630 | 0.85 | 0.551*** | 0.442*** | 0.993 |
| 28 | 0.582*** | 0.307*** | 0.889 | 2467 | 0.75 | 0.549*** | 0.341*** | 0.89 |
| 29 | 0.675*** | 0.213*** | 0.888 | 2557 | 0.79 | 0.617*** | 0.237*** | 0.854 |
| 31 | 0.677*** | 0.266*** | 0.943 | 1061 | 0.8 | 0.643*** | 0.300*** | 0.943 |
| 32 | 0.579*** | 0.272*** | 0.851 | 284 | 0.74 | 0.558*** | 0.561*** | 1.119 |
| 33 | 0.649*** | 0.188*** | 0.837 | 442 | 0.75 | 0.623*** | 0.248*** | 0.871 |
| 34 | 0.668*** | 0.334*** | 1.002 | 595 | 0.83 | 0.626*** | 0.327*** | 0.953 |
| 35 | 0.667*** | 0.184*** | 0.851 | 299 | 0.78 | 0.702*** | 0.213*** | 0.915 |
| 36 | 0.652*** | 0.322*** | 0.974 | 940 | 0.86 | 0.609*** | 0.306*** | 0.915 |
| 37 | 0.451*** | 0.309*** | 0.76 | 181 | 0.56 | 0.372*** | 0.355*** | 0.727 |

Industries: 15-Food products and beverages; 17-Textiles; 18-Wearing apparel; 19-Leather manufacturing; 20-Wood and wood and cork products, except furniture; 21-Pulp, paper and paper products; 22-Publishing and printing; 24-Chemicals and chemical products; 25-Rubber and plastic products; 26-Non-metallic mineral products; 27-Basic metals; 28-Fabricated metal products, except machinery and equipment; 29-Machinery and equipment n.e.c.; 31-Electrical machinery and apparatus n.e.c.; 32-Radio, television and communication equipment and apparatus; 33-Medical, precision and optical instruments; 34-Motor vehicles, trailers; 35-Other transport equipment; 36-Furniture; manufacturing n.e.c.; 37-Recycling

Figure 1. The marginal effect of a change in competition on firm productivity




(a) The marginal effect of an increase in tariff on firm productivity

(b) The marginal effect of an increase in domestic competition on firm productivity

Regarding the impact of an increase in domestic competition, its effect has been negative in markets with already tough competition but has been positive in concentrated markets. This result is in line with theoretical results that point to an inverted U-shape relationship between competition and firm productivity. Given that at the level of industry aggregation that we have in our data, the markets are highly competitive (as indicated by the sample mean of 0.013 for the Herfindal index and by its 0.039 standard deviation), in most of the industries the impact of an increase in domestic competition on firm productivity has been positive (see Figure 1, (b)). There are, however, examples of the opposite effects as well, mostly among sub-industries of textile manufacturing (ISIC 1700) and in the manufacture of aircraft and spacecraft (ISIC 3530).

Estimates of equation (6) show that companies with different levels of efficiency respond differently to trade liberalization and to an increase in domestic competition, as all the interaction terms between competition and the level of firm inefficiency are highly significant (see Table 4, column (2)). Moreover, we can see from Table 4, column (2), that for highly inefficient firms (firms with a $d_{it-1}$ closed to 1), both the first and the second order effects of a tariff reduction and of a decrease in competition on firm productivity decrease substantially. This indicates that the productivity of laggard companies does not to respond to changes in competition. However, frontier companies are affected by both, domestic and foreign competition (these effects should be close to the effects inferred from competition measures that are not interacted with distance as the highly efficient companies have a $d_{it-1}$ closed to 0).

The fact that changes in competition levels have different impacts for frontier than for laggard companies is further confirmed by our estimations of equation (5) on subsamples of efficient and inefficient companies (see Table 4, columns (3) and (4)). Thus, our results are in line with the predictions of the theoretical models developed by Boone (2000) and Aghion et al (2005b). Regarding the marginal effects of an increase in competition on firm productivity, for the highly productive firms, the positive relation between a decrease in tariff and firm productivity is less likely to hold now (Table 4, column (4)) than in the case when we estimate this effect using the entire sample (Table 4, column (1)). The opposite is true, however, for the positive impact of an increase in competition on firm productivity.

Table 4. The impact of competition on firm productivity[8]

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | All firms | All firms | Low Prod | High Prod |
| lag Tariff rates | -0.041*** (3.80) | -0.080*** (4.69) | -0.036 (1.16) | -0.076** (2.68) |
| *square* | 0.001*** (3.43) | 0.003*** (4.67) | 0.001 (1.09) | 0.003** (2.53) |
| ** lagged inefficiency* ($d_{it-1}$) | | 0.062** (2.02) | | |
| *square * lagged inefficiency* ($d_{it-1}$) | | -0.002** (2.13) | | |
| lag Herfindal | 2.433** (2.04) | 5.457*** (4.09) | -0.250 (0.15) | 5.161** (2.43) |
| *square* | -6.720** (2.42) | -11.248*** (3.54) | -3.474 (0.80) | -9.697** (2.30) |
| ** lagged inefficiency* ($d_{it-1}$) | | -5.437*** (3.09) | | |
| *square * lagged inefficiency* ($d_{it-1}$) | | 9.274*** (2.74) | | |
| lagged inefficiency ($d_{it-1}$) | | -1.177*** (8.15) | | |
| Constant | 0.059 (0.98) | 0.620*** (6.40) | -0.401** (2.57) | 0.571*** (4.31) |
| Observations | 7158 | 6988 | 725 | 1096 |
| R-squared | 0.04 | 0.34 | 0.17 | 0.23 |

t-statistic in parentheses; *** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level. Robust errors adjusted for clustering at 3-digit level in regressions (1) and (2) and to two digit level, due to smaller number of observations, in regressions (3) and (4). Year and industry dummies at 2 digit level. Base year: 1996

We have further estimated the models (5) and (6) using only the level of tariff protection as a competition measure to see if in the absence of a control for domestic competition, the effect of trade liberalization on firm productivity is biased. The results are given in Table (5). When comparing these results with the ones in Table 4 we see that in the former estimates the impact of trade liberalization is underestimated (see results in columns (1) in both tables). Yet, the importance of the initial firm efficiency is seriously downplayed, the effects of the interaction terms between trade liberalization and the level of firm inefficiency being insignificant in Table 5, column (2), and having coefficients much closer to zero and lower

[8] We got the same results when using industry dummies at 3 digit level in regressions (1)-(4), or when interacting industries dummies with the productivity distance in regressions (3) and (4). The results in regressions (5)-(8) do not change when we define low (high) productive companies as being the ones with a productivity distance less (higher) than 0.1 (0.9). We have experimented with dummies for exporting industries, for companies that exit the market, and with variables that differentiate between companies that produce goods within different industries at NACE 4-digit. Since none of these variables were significant, we have dropped them. We have also normalized the competition measures on industrial output rather than on the sum of industrial output and imports. The results are similar with the ones in the table above.

significance in regressions run on the subsample of highly productive firms (Table 5, column (4)).

Table 5. The impact of trade liberalization on firm productivity (without domestic competition)

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | All | All | Low | High |
| lag Tariff rates | -0.009**<br>(2.28) | -0.016**<br>(2.30) | 0.005<br>(0.65) | -0.019*<br>(1.95) |
| *square* | 0.000*<br>(1.90) | 0.000***<br>(2.65) | -0.000<br>(0.15) | 0.000**<br>(2.36) |
| * *lagged inefficiency* ($d_{it-1}$) | | 0.009<br>(1.07) | | |
| *square * lagged inefficiency* ($d_{it-1}$) | | -0.000<br>(1.25) | | |
| lagged inefficiency ($d_{it-1}$) | | -0.943***<br>(14.45) | | |
| Constant | -0.038<br>(0.97) | 0.394***<br>(7.27) | -0.569***<br>(13.84) | 0.399***<br>(7.24) |
| Observations | 12742 | 12338 | 1370 | 2029 |
| R-squared | 0.03 | 0.29 | 0.12 | 0.14 |

t-statistic in parentheses; *** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level. Robust errors adjusted for clustering at 3-digit level in regressions (1) and (2) and to two digit level, due to smaller number of observations, in regressions (3) and (4). Year and industry dummies at 2 digit level. Base year: 1996

In general our results are robust to the two alternative measures of domestic competition we use, Herfindal and Mkt concentration, as the results in Appendix 2, Table 2.1 closely match the results in Table 4, the only difference being that although the square term of market concentration remains negative, it looses its significance. Also, the results in Appendix 2, Tables 2.2 and 2.3 show that using OLS and CRS_OP productivities we get the same results, with slightly less significance in the coefficients for the latter case.

## 5. Conclusions

In this paper we have studied the impact of competition on firm performance in the Czech Republic. We have found that laggard and frontier firms respond differently to an increase in domestic competition and to trade liberalization. Firms that are close to the technological frontier benefit from trade liberalization. Also, they are affected by changes in domestic competition: an increase in competition has a positive impact on firm productivity in concentrated markets but has the opposite effect on firms with tough competition. We found no effect of trade liberalization or competition on firm productivity in laggard companies. The results also indicate a non-linear effect from competition to productivity and are in line with the prediction of the theoretical models developed by Boone (2000) and Aghion et al (2005b). Furthermore, our results indicate that in the absence of a control for domestic competition, the impact of trade liberalization on firm productivity is understated. Meanwhile, in this case the role played by the initial firm efficiency in determining the effect of an increase in competition on firm productivity is seriously downplayed.

## References


Ackerberg, D., L. Benkard, S. Berry, and A. Pakes (2005): Econometric Tools for Analyzing Market Outcomes, to appear in the *Handbook of Econometrics* Volume 6, J.J. Heckman.

Aghion, P., N. Bloom, R. Blundell, R. Griffith, and P. Howitt (2005a): Competition and Innovation: An Inverted U Relationship, *Quarterly Journal of Economics* 120(2): 701-728

Aghion, P., R. Burgess, S.J. Redding, and F. Zilibotti (2005b): Entry Liberalization and Inequality in Industrial Performance, *Journal of the European Economic Association* 3(2-3): 291-302.

Amiti, M. and J. Konings (2007): Trade Liberalization, Intermediate Inputs and Productivity: Evidence from Indonesia, *American Economic Review*, forthcoming.

Arrow, K. (1962): Economic Welfare and the Allocation of Resources for Inventions, in *The Rate and Direction of Inventive Activity*, ed. R. Nelson, Princeton University Press.

Bernard, A.B., J.B. Jensen and P.K. Schott (2006): Trade Costs, Firms and Productivity, *Journal of Monetary Economics* 53(5): 917-937.

Bessonova, E., K. Kozlov and K. Yudaeva (2003): Trade Liberalization, Foreign Direct Investment, and Productivity of Russian Firms, *CEFIR Working Papers* w0035.

Blundell, R. and S. Bond (1998): Initial Conditions and Moment Restrictions in Dynamic Panel Data Models, *Journal of Econometrics* 87: 115-143.

Blundell, R. and S. Bond (2000): GMM Estimantion with Persistent Panel Data: An Application to Production Functions, *Econometric Reviews* 19(3).

Boone, J. (2000): Competitive Pressure: The Effects on Investments in Product and Process Innovation, *RAND Journal of Economics* 31(3): 549-569.

Djankov, S. and P. Murell (2002): Enterprise Restructuring in Transition: A Quantitative Survey, *Journal of Economic Literature* 40: 739-792.

Good, D.H., M.I. Nadiri and R.C. Sickles (1996): "Index Number and Factor Demand Approaches to the Estimation of Productivity," *NBER Working Paper* 5790.

Green, A. and D. Mayes (1991): Technical Inefficiency in Manufacturing Industries, *The Economic Journal* 101: 523-538.

Hart, O.D. (1983): The Market Mechanism as an Incentive Scheme, *The Bell Journal of Economics* 14: 366-382.

Hermalin, B.E. (1992): The Effects of Competition on Executive Behavior, *RAND Journal of Economics* 23(3): 350-365.

Keller, W. (2004): International Technology Diffusion, *Journal of Economic Literature* 42(3): 752-782.

Konings, J. and H. Vandenbussche (2007): Antidumping Protection and Productivity of Domestic Firms: A Firm Level Analysis, *mimeo*.

Lawrence, R.Z. (2000): Does a Kick in the Pants Get You Going or Does it Just Hurt? The Impact of International Competition on Technological Change in US Manufacturing, in Feenstra, R.E. ed., *The Impact of International Trade on Wages*, University of Chicago Press for the National Bureau of Economic Research, pp. 197–224.

Levinsohn, J. and A. Petrin (2003): Estimating Production Functions Using Inputs to Control for Unobservables, *Review of Economic Studies* 70(2): 317-341.

MacDonald, J.M. (1994): Does import competition force efficient production? *Review of Economics and Statistics* 76(4): 721–727.

Martin, S. (1993): Endogenous Firm Efficiency in a Cournot Principal-Agent Model, *Journal of Economic Theory* 59: 445-450.

Meyer, M.A. and J. Vickers (1997): Performance Comparisons and Dynamic Incentives, *Journal of Political Economy* 105(3): 547-81.

Nalebuff, B.J. and J.E. Stiglitz (1983): Information, Competition, and Markets, *American Economic Review* 73: 278-283.

Nickell, S.J. (1996): Competition and Corporate Performance, *Journal of Political Economy* 104(4): 724-746.

Nickell, S.J. (1994): Competition and Corporate Performance, *Discussion Paper* 182, London School of Economics, Centre for Economic Performance.

Nickell, S.J., S.B. Wadhwani and M. Wall (1992): Productivity Growth in U.K. Companies, 1975-1986, *European Economic Review* 36: 1055-1085.

Olley, G.S. and A. Pakes (1996): The Dynamics of Productivity in the Telecommunications Equipment Industry, *Econometrica* 64(6): 1263-1297.

Pavcnik, N. (2002): Trade Liberalization, Exit, and Productivity Improvements: Evidence from Chilean Plants, *Review of Economic Studies* 69(1): 245-276.

Romer, P. (1994): New Goods, Old Theory and the Welfare Cost of Trade Restrictions, *Journal of Development Economics* 43(1): 5-38.

Sabirianova, K., J. Svenjar and K. Terrell (2005): Distance to the Efficiency Frontier and FDI Spillovers, *Journal of the European Economic Association* 3(2-3): 576-586.

Scharfstein (1988): Product-market competition and managerial slack, *RAND Journal of Economics* 19(1): 147-155.

Scherer, F. (1967): Market Structure and the Employment of Scientists and Engineers, *American Economic Review* 57: 524-531.

Schmidt, K.M. (1997): Managerial Incentives and Product Market Competition, *Review of Economic Studies* 64: 191-213.

Schumpeter, J. (1934): *The Theory of Economic Development*, Cambridge, MA: Harvard University Press.

Schumpeter, J. (1942): *Capitalism, Socialism and Democracy*, New York: Harper.

Topalova, P. (2004): Trade Liberalization and Firm Productivity: the Case of India, *IMF Working Papers* 04/28.

Tybout, J. (2003): Plant- and Firm-level Evidence on 'New' Trade Theories, in Choi, E.K., Harrigan, J. (Eds.), *Handbook of International Economics*, Basil-Blackwell, Oxford.

Winters, L Alan (2004): Trade Liberalization and Economic Performance: An Overview, *The Economic Journal* 114(2): F4-F21.

## Appendix 1 – Data description

Firm level data are from Amadeus. Amadeus is a pan-European commercial database, provided by Bureau van Dijk, which contains financial information on public and private companies. We used data from all versions of the Amadeus database since 1996 with information on medium and large firms. Most of the Czech firms included in the database produce goods in several industries at 4 digit NACE level. We have classified firms according to their main activity.

We did the following modifications to the data:
i. we excluded all companies that had less than 10 employees:
ii. we excluded firms with non-positive investment levels when estimating firm productivity
iii. since we did not have enough observations in three industries at 2-digit NACE level (16 – manufacture of tobacco, 23 – manufacture of coke, refined petroleum and nuclear fuel, 30 – manufacture of office machinery and computers) to estimate the production function we dropped companies from this sector.
iv. we dropped 2 observations to exclude firms with market shares higher than 100.
v. we dropped 6 observations to exclude firms with a productivity index less than -5 as they looked to be outliers (see Figure A1.4).

Table A1.1. Variables

| *Variable* | *Definition* |
|---|---|
| *y* (log of output) | Added value deflated by the producer price index (PPI). For most of the industries, we have the PPI at 3-digit NACE; for the remaining we have used PPI at 2-digit NACE.[9]<br>Sources: Added value is from Amadeus and Aspekt; PPI from the Czech Statistical Office.<br>Coverage: 1993-2005 |
| *k* (capital) | Tangible fixed assets deflated by the price index for gross fixed capital formation, at a slightly more aggregated level than 2-digit NACE.<br>Sources: Tangible fixed assets are from Amadeus and Aspekt; price index for gross fixed capital formation from AMECO.<br>Coverage: 1993-2005 |
| *l* (log of labour) | Number of employees.<br>Sources: Amadeus and Aspekt<br>Coverage: 1994-2005 |
| *i* (investment) | Computed as $i_{it} = k_{it+1} - (1-\delta)k_{it}$, where $\delta = 15\%$.<br>Coverage: 1993-2004 |
| Tariff rate | Weighted average (by trade value) of effectively applied rates, taking into consideration applicable (and available) preferential duties.<br>Source: WTO<br>Coverage: 1994-2004 |
| Herfindal | Number of companies in a 4-digit ISIC industry<br>Sources: UNIDO via Campus Solutions.<br>Coverage: 1995-2003 |

[9] Mairesse and Jaumandreu (2005) show that deflating value added with PPI rather than a firm specific price index leads to very similar estimates of the coefficients in the production function.

| | |
|---|---|
| Mkt concentration | The ratio of the sales of the 4 companies with the biggest sales and the industrial output, at 4-digit ISIC level.<br>Sources: Firm sales are from Amadeus and Aspekt; industrial output is from UNIDO via Campus Solutions.<br>Coverage: 1995-2003 |
| Inefficiency ($d_{it}$) | = (Max(productivity)-productivity) / (Max(productivity)-Min(productivity) at 4-digit NACE level |

Table A1.2. Descriptive statistics – observations based on which firm productivity is estimated

| Variable | | Mean | Std. Dev. | Min | Max | Observations |
|---|---|---|---|---|---|---|
| y | overall | 6.197 | 1.335 | 0.118 | 12.359 | N = 19940 |
| | between | | 1.312 | 0.442 | 11.880 | n = 5338 |
| | within | | 0.389 | 0.342 | 9.088 | T-bar = 3.73548 |
| k | overall | 6.265 | 1.770 | 0.041 | 12.991 | N = 19940 |
| | between | | 1.881 | 0.041 | 12.665 | n = 5338 |
| | within | | 0.351 | 1.402 | 10.161 | T-bar = 3.73548 |
| l | overall | 5.224 | 1.153 | 2.303 | 10.129 | N = 19940 |
| | between | | 1.180 | 2.303 | 10.005 | n = 5338 |
| | within | | 0.233 | 2.445 | 7.413 | T-bar = 3.73548 |
| i | overall | 0.505 | 2.826 | 0.000004 | 125.106 | N = 19940 |
| | between | | 1.594 | 0.000 | 74.944 | n = 5338 |
| | within | | 1.386 | -45.009 | 87.663 | T-bar = 3.73548 |
| OP productivity | overall | 1.190 | 0.873 | -5.069 | 5.283 | N = 19940 |
| | between | | 0.816 | -3.217 | 4.949 | n = 5338 |
| | within | | 0.367 | -4.478 | 3.982 | T-bar = 3.73548 |

Table A1.3a. Descriptive statistics – observations based on which the impact of competition on firm productivity is estimated

| Variable | | Mean | Std. Dev. | Min | Max | Observations |
|---|---|---|---|---|---|---|
| lav_real | overall | 6.354 | 1.249 | 0.118 | 11.748 | N = 7158 |
| | between | | 1.277 | 0.118 | 11.343 | n = 2249 |
| | within | | 0.296 | 1.495 | 8.458 | T-bar = 3.18275 |
| k | overall | 6.483 | 1.550 | 0.445 | 12.192 | N = 7158 |
| | between | | 1.668 | 0.445 | 12.109 | n = 2249 |
| | within | | 0.254 | 3.740 | 8.187 | T-bar = 3.18275 |
| l | overall | 5.347 | 1.063 | 2.303 | 9.842 | N = 7158 |
| | between | | 1.114 | 2.303 | 9.842 | n = 2249 |
| | within | | 0.209 | 3.384 | 6.822 | T-bar = 3.18275 |
| i | overall | 0.421 | 1.725 | 0.000 | 60.730 | N = 7158 |
| | between | | 1.289 | 0.000 | 35.192 | n = 2249 |
| | within | | 0.957 | -22.484 | 31.855 | T-bar = 3.18275 |
| OP productivity | overall | 1.163 | 0.791 | -4.211 | 5.283 | N = 7158 |
| | between | | 0.745 | -4.211 | 5.070 | n = 2249 |
| | within | | 0.284 | -3.283 | 3.190 | T-bar = 3.18275 |
| Tariff rate | overall | 6.702 | 4.657 | 0.000 | 27.530 | N = 7158 |
| | between | | 4.403 | 0.005 | 27.530 | n = 2249 |
| | within | | 1.028 | -7.674 | 27.036 | T-bar = 3.18275 |
| Herfindal | overall | 0.010 | 0.027 | 0.000 | 0.626 | N = 7158 |
| | between | | 0.022 | 0.000 | 0.360 | n = 2249 |
| | within | | 0.017 | -0.308 | 0.564 | T-bar = 3.18275 |
| Mkt concentration | overall | 0.126 | 0.107 | 0.001 | 1.006 | N = 7158 |
| | between | | 0.099 | 0.001 | 0.952 | n = 2249 |
| | within | | 0.053 | -0.336 | 0.909 | T-bar = 3.18275 |

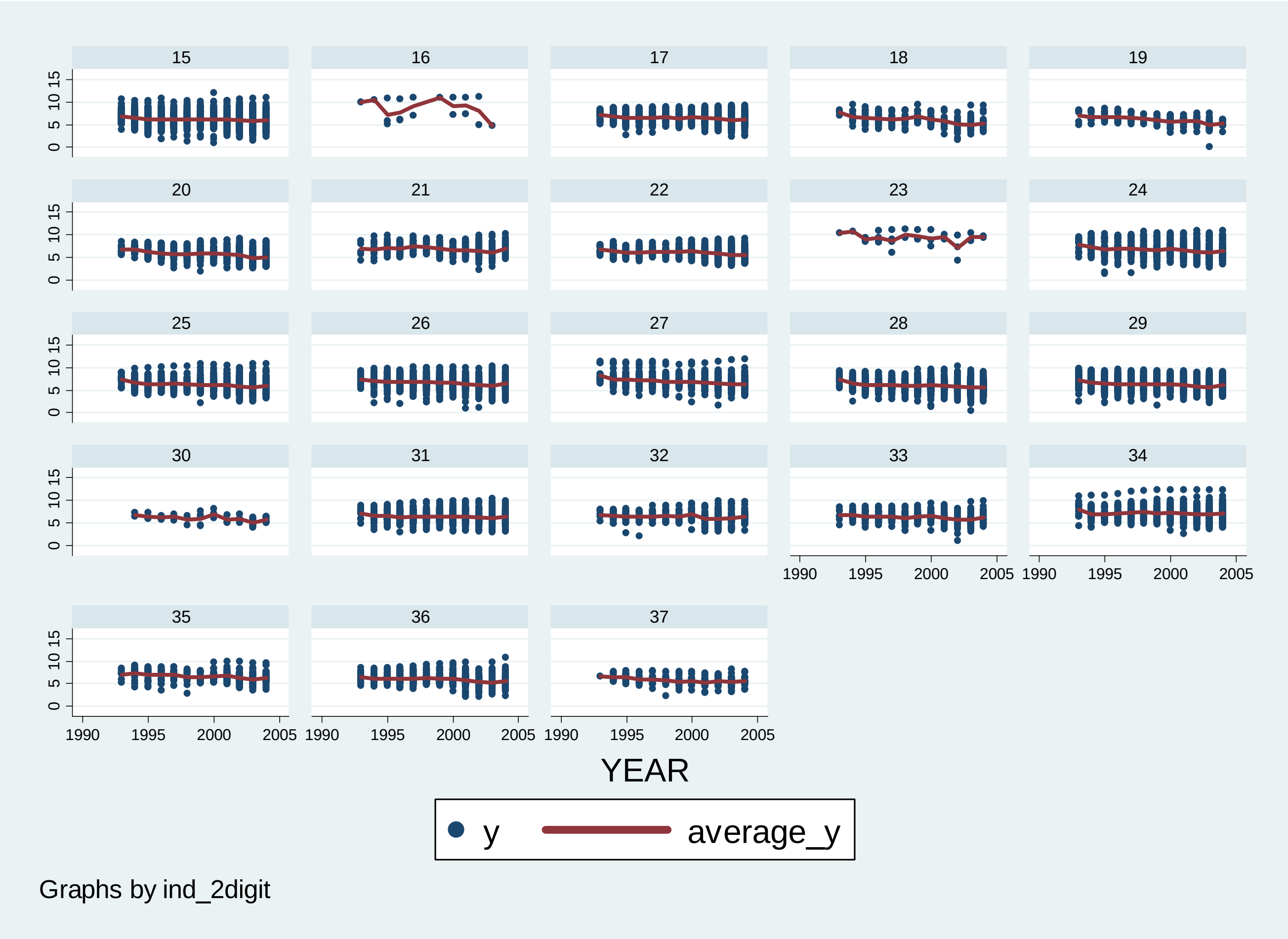
Table A1.3b. Descriptive statistics – low productivity firms in 1995

| Variable | | Mean | Std. Dev. | Min | Max | Observations |
|---|---|---|---|---|---|---|
| lav_real | overall | 6.245 | 1.091 | 2.010 | 9.303 | N = 725 |
| | between | | 1.091 | 3.527 | 9.060 | n = 158 |
| | within | | 0.408 | 1.385 | 8.036 | T-bar = 4.58861 |
| k | overall | 6.747 | 1.163 | 2.670 | 10.933 | N = 725 |
| | between | | 1.246 | 3.947 | 10.933 | n = 158 |
| | within | | 0.253 | 5.167 | 8.327 | T-bar = 4.58861 |
| l | overall | 5.460 | 0.959 | 2.996 | 9.842 | N = 725 |
| | between | | 0.993 | 2.996 | 9.842 | n = 158 |
| | within | | 0.207 | 4.401 | 6.309 | T-bar = 4.58861 |
| i | overall | 0.312 | 0.578 | 0.000 | 5.558 | N = 725 |
| | between | | 0.701 | 0.004 | 5.558 | n = 158 |
| | within | | 0.307 | -1.128 | 3.153 | T-bar = 4.58861 |
| OP productivity | overall | 0.916 | 0.774 | -2.971 | 2.976 | N = 725 |
| | between | | 0.707 | -1.525 | 2.761 | n = 158 |
| | within | | 0.378 | -3.529 | 2.458 | T-bar = 4.58861 |
| Tariff rate | overall | 6.162 | 3.821 | 0.010 | 27.530 | N = 725 |
| | between | | 3.231 | 0.010 | 21.035 | n = 158 |
| | within | | 1.052 | 1.272 | 13.432 | T-bar = 4.58861 |
| Herfindal | overall | 0.013 | 0.039 | 0.000 | 0.416 | N = 725 |
| | between | | 0.036 | 0.000 | 0.302 | n = 158 |
| | within | | 0.023 | -0.168 | 0.245 | T-bar = 4.58861 |
| Mkt concentration | overall | 0.123 | 0.124 | 0.003 | 1.006 | N = 725 |
| | between | | 0.125 | 0.008 | 0.833 | n = 158 |
| | within | | 0.066 | -0.327 | 0.648 | T-bar = 4.58861 |

Table A1.3c. Descriptive statistics – high productivity firms in 1995

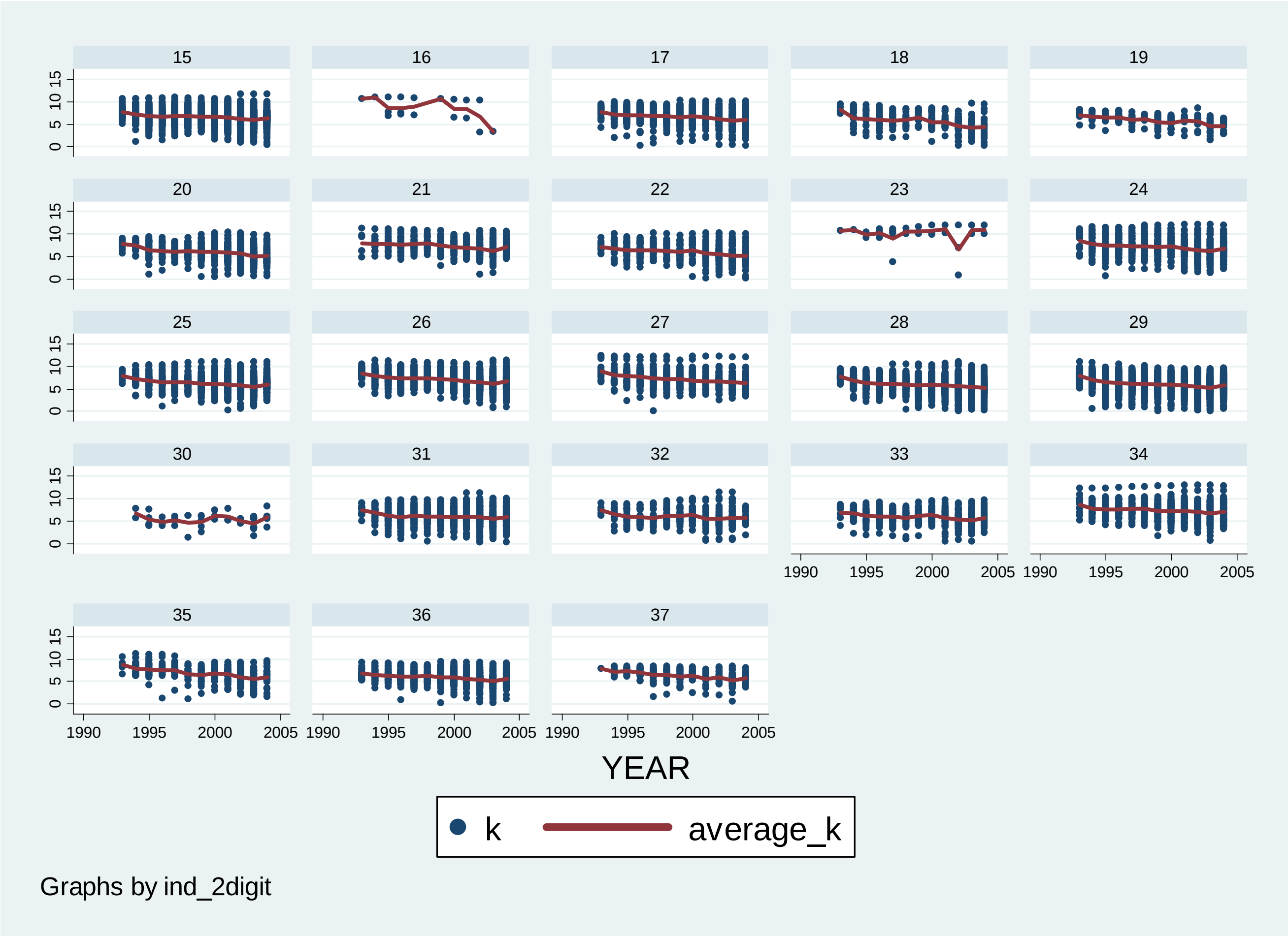
| Variable | | Mean | Std. Dev. | Min | Max | Observations |
|---|---|---|---|---|---|---|
| lav_real | overall | 7.110 | 1.250 | 4.041 | 11.748 | N = 1096 |
| | between | | 1.247 | 4.370 | 11.343 | n = 211 |
| | within | | 0.257 | 5.760 | 8.231 | T-bar = 5.19431 |
| k | overall | 7.130 | 1.593 | 1.977 | 12.192 | N = 1096 |
| | between | | 1.646 | 2.785 | 12.109 | n = 211 |
| | within | | 0.266 | 5.428 | 8.478 | T-bar = 5.19431 |
| l | overall | 5.869 | 1.065 | 2.996 | 9.782 | N = 1096 |
| | between | | 1.094 | 2.996 | 9.615 | n = 211 |
| | within | | 0.224 | 4.977 | 6.631 | T-bar = 5.19431 |
| i | overall | 0.807 | 2.946 | 0.000 | 60.730 | N = 1096 |
| | between | | 2.749 | 0.002 | 35.192 | n = 211 |
| | within | | 1.613 | -22.098 | 26.345 | T-bar = 5.19431 |
| OP productivity | overall | 1.458 | 0.830 | -0.977 | 4.274 | N = 1096 |
| | between | | 0.757 | -0.283 | 3.840 | n = 211 |
| | within | | 0.260 | 0.150 | 2.464 | T-bar = 5.19431 |
| Tariff rate | overall | 7.261 | 4.719 | 0.000 | 27.530 | N = 1096 |
| | between | | 4.130 | 0.005 | 21.635 | n = 211 |
| | within | | 1.281 | 1.366 | 21.329 | T-bar = 5.19431 |
| Herfindal | overall | 0.014 | 0.036 | 0.000 | 0.626 | N = 1096 |
| | between | | 0.022 | 0.000 | 0.164 | n = 211 |
| | within | | 0.029 | -0.106 | 0.567 | T-bar = 5.19431 |
| Mkt concentration | overall | 0.144 | 0.130 | 0.005 | 1.006 | N = 1096 |
| | between | | 0.108 | 0.007 | 0.633 | n = 211 |
| | within | | 0.073 | -0.132 | 0.926 | T-bar = 5.19431 |

Figure A1.1: Log of value added by industry 1993 – 2005.



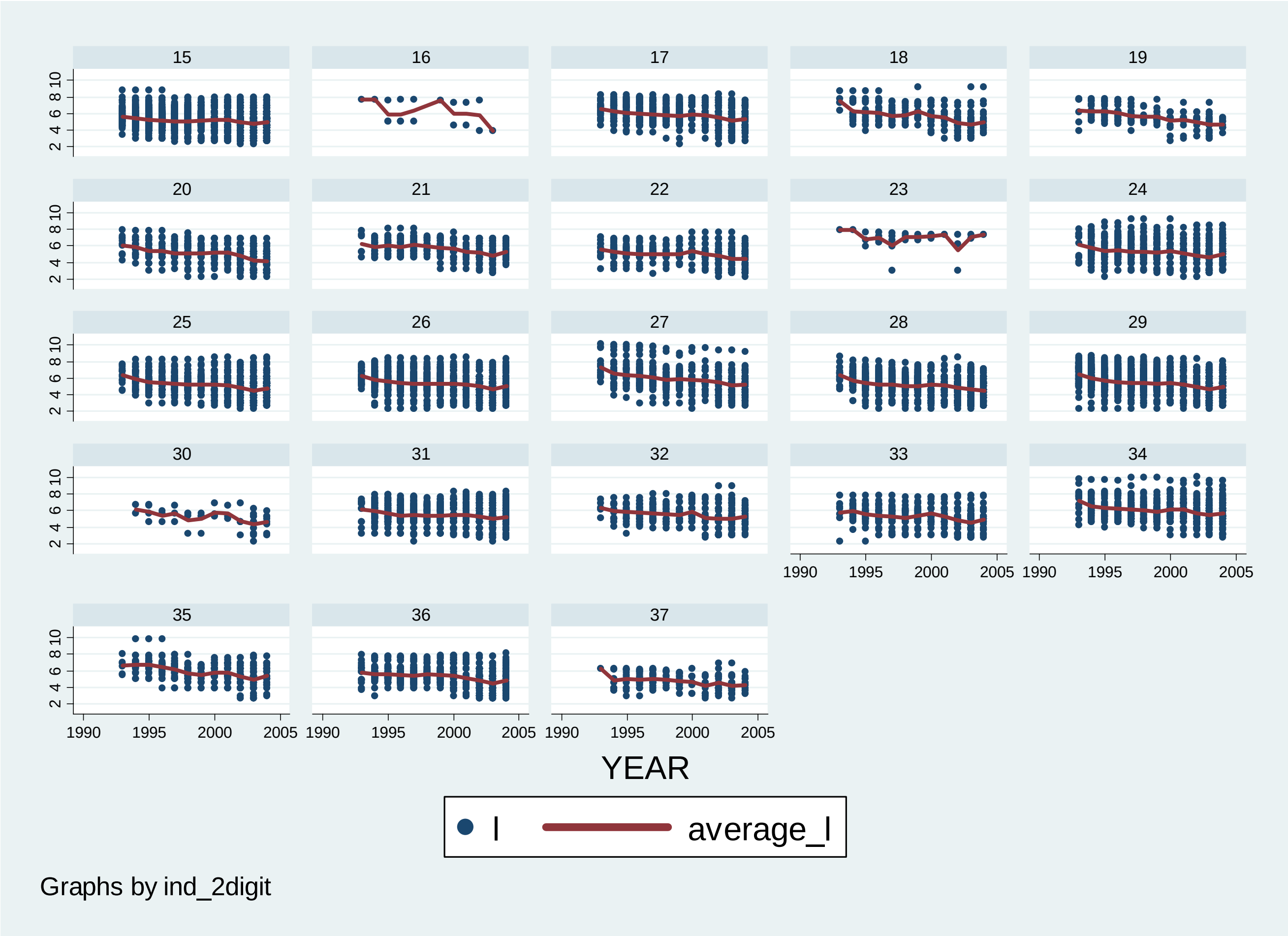

Industries: 15-Food products and beverages; 16-Tobacco products; 17-Textiles; 18-Wearing apparel; 19-Leather manufacturing; 20-Wood and wood and cork products, except furniture; 21-Pulp, paper and paper products; 22-Publishing and printing; 23-Coke, refined petroleum products and nuclear fuel; 24-Chemicals and chemical products; 25-Rubber and plastic products; 26-Non-metallic mineral products; 27-Basic metals; 28-Fabricated metal products, except machinery and equipment; 29-Machinery and equipment n.e.c.; 30-Office machinery and computers; 31-Electrical machinery and apparatus n.e.c.; 32-Radio, television and communication equipment and apparatus; 33-Medical, precision and optical instruments; 34-Motor vehicles, trailers; 35-Other transport equipment; 36-Furniture; manufacturing n.e.c.; 37-Recycling

Figure A1.2: Log of capital by industries 1993 - 2005.



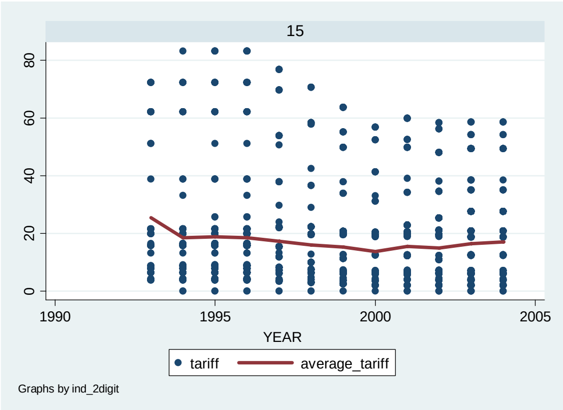

Industries: 15-Food products and beverages; 16-Tobacco products; 17-Textiles; 18-Wearing apparel; 19-Leather manufacturing; 20-Wood and wood and cork products, except furniture; 21-Pulp, paper and paper products; 22-Publishing and printing; 23-Coke, refined petroleum products and nuclear fuel; 24-Chemicals and chemical products; 25-Rubber and plastic products; 26-Non-metallic mineral products; 27-Basic metals; 28-Fabricated metal products, except machinery and equipment; 29-Machinery and equipment n.e.c.; 30-Office machinery and computers; 31-Electrical machinery and apparatus n.e.c.; 32-Radio, television and communication equipment and apparatus; 33-Medical, precision and optical instruments; 34-Motor vehicles, trailers; 35-Other transport equipment; 36-Furniture; manufacturing n.e.c.; 37-Recycling

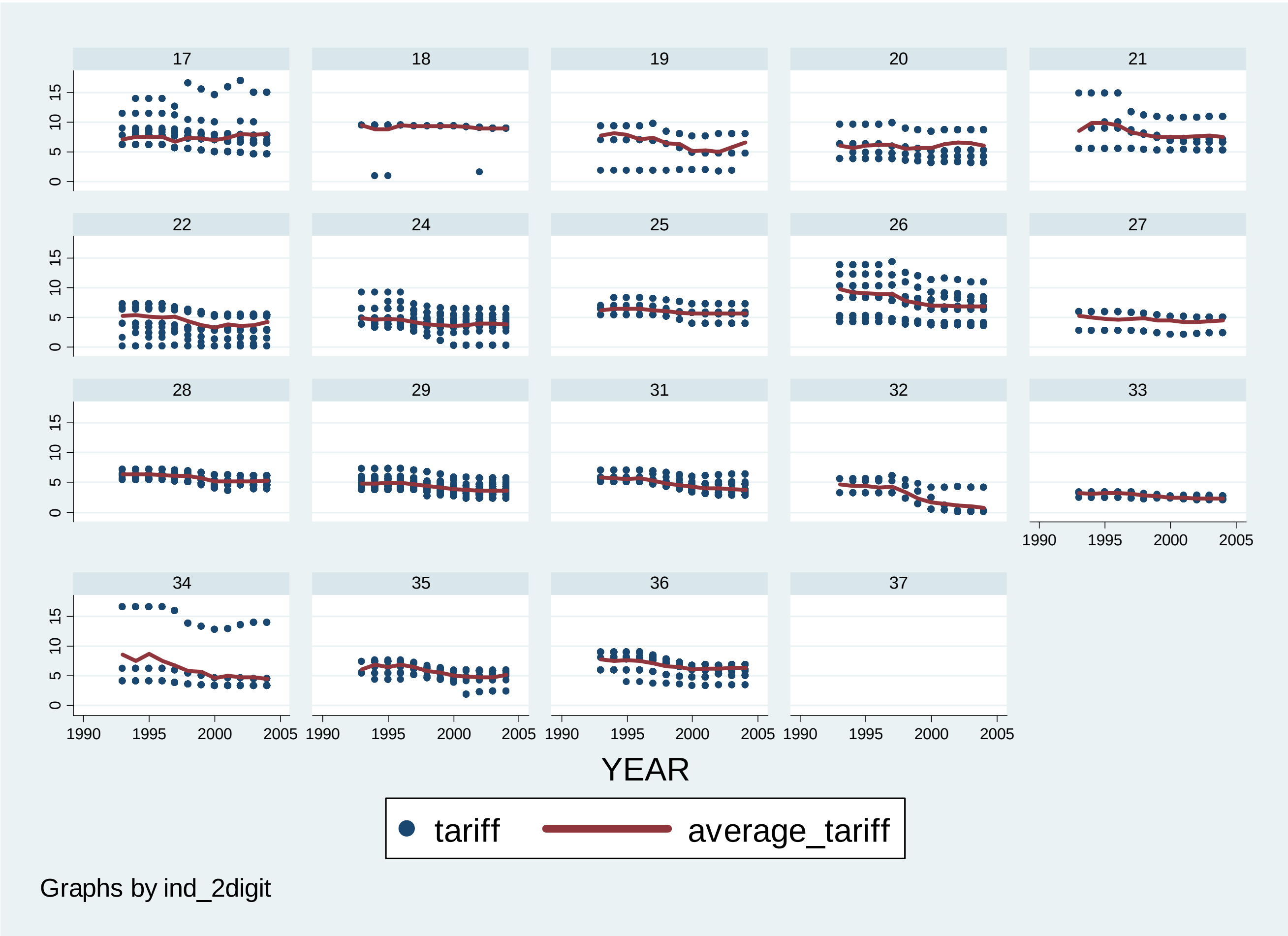
Figure A1.3: Log of employment by industry 1993 – 2005.




Industries: 15-Food products and beverages; 16-Tobacco products; 17-Textiles; 18-Wearing apparel; 19-Leather manufacturing; 20-Wood and wood and cork products, except furniture; 21-Pulp, paper and paper products; 22-Publishing and printing; 23-Coke, refined petroleum products and nuclear fuel; 24-Chemicals and chemical products; 25-Rubber and plastic products; 26-Non-metallic mineral products; 27-Basic metals; 28-Fabricated metal products, except machinery and equipment; 29-Machinery and equipment n.e.c.; 30-Office machinery and computers; 31-Electrical machinery and apparatus n.e.c.; 32-Radio, television and communication equipment and apparatus; 33-Medical, precision and optical instruments; 34-Motor vehicles, trailers; 35-Other transport equipment; 36-Furniture; manufacturing n.e.c.; 37-Recycling

Figure A1.4. Tariff protection by industry (due to much higher tariffs, industry 15 has a different scale than the other industries and is therefore depicted in a separate graph).




Industries: 15-Food products and beverages; 17-Textiles; 18-Wearing apparel; 19-Leather manufacturing; 20-Wood and wood and cork products, except furniture; 21-Pulp, paper and paper products; 22-Publishing and printing; 24-Chemicals and chemical products; 25-Rubber and plastic products; 26-Non-metallic mineral products; 27-Basic metals; 28-Fabricated metal products, except machinery and equipment; 29-Machinery and equipment n.e.c.; 31-Electrical machinery and apparatus n.e.c.; 32-Radio, television and communication equipment and apparatus; 33-Medical, precision and optical instruments; 34-Motor vehicles, trailers; 35-Other transport equipment; 36-Furniture; manufacturing n.e.c.; 37-Recycling

## Appendix 2 – Robustness checks

Tabel A2.1. The impact of competition of firm productivity if market concentration rather than the Herfindal index is used to measure domestic competition

| | (2) | (4) | (6) | (8) |
|---|---|---|---|---|
| | All firms | All firms | Low Prod | High Prod |
| lag Tariff rates | -0.039***<br>(3.55) | -0.072***<br>(4.31) | -0.038<br>(1.17) | -0.068**<br>(2.55) |
| *square* | 0.001***<br>(3.28) | 0.003***<br>(4.24) | 0.001<br>(1.10) | 0.002**<br>(2.42) |
| ** lagged inefficiency ($d_{it-1}$)* | | 0.051*<br>(1.72) | | |
| *square * lagged inefficiency ($d_{it-1}$)* | | -0.002*<br>(1.71) | | |
| lag Mkt concentration | 0.915***<br>(3.37) | 1.795***<br>(5.14) | 0.392<br>(0.95) | 1.539**<br>(2.43) |
| *square* | -0.965<br>(1.54) | -1.683***<br>(3.19) | -0.944*<br>(1.94) | -1.099<br>(1.43) |
| ** lagged inefficiency ($d_{it-1}$)* | | -1.959***<br>(3.74) | | |
| *square * lagged inefficiency ($d_{it-1}$)* | | 1.912**<br>(2.15) | | |
| lagged inefficiency ($d_{it-1}$) | | -1.001***<br>(6.72) | | |
| Constant | -0.029<br>(0.42) | 0.451***<br>(4.11) | -0.424**<br>(2.53) | 0.406**<br>(2.87) |
| Observations | 7158 | 6988 | 725 | 1096 |
| R-squared | 0.05 | 0.34 | 0.17 | 0.24 |

t-statistic in parentheses; *** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level. Robust errors adjusted for clustering at 3-digit level in regressions (1) and (2) and to two digit level, due to smaller number of observations, in regressions (3) and (4). Year and industry dummies at 2 digit level. Base year: 1996

Tabel A2.2. The impact of competition of firm productivity using OLS Productivity

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | All firms | All firms | All firms | All firms | Low Prod | Low Prod | High Prod | High Prod |
| lag Tariff rates | -0.028*** (3.33) | -0.027*** (3.11) | -0.071*** (5.41) | -0.066*** (5.11) | -0.019 (0.90) | -0.020 (0.87) | -0.069*** (3.61) | -0.062*** (3.61) |
| *square* | 0.001*** (2.87) | 0.001*** (2.68) | 0.003*** (5.64) | 0.002*** (5.18) | 0.001 (0.77) | 0.001 (0.76) | 0.003*** (3.38) | 0.002*** (3.36) |
| ** lagged inefficiency ($d_{it-1}$)* | | | 0.075*** (3.20) | 0.066*** (2.91) | | | | |
| *square *lagged inefficiency ($d_{it-1}$)* | | | -0.003*** (3.63) | -0.003*** (3.18) | | | | |
| lag Herfindal | 1.756** (2.15) | | 3.529*** (3.20) | | -0.169 (0.11) | | 3.163** (2.29) | |
| *square* | -5.415** (2.60) | | -8.523*** (3.22) | | -3.135 (0.75) | | -5.969** (2.24) | |
| ** lagged inefficiency ($d_{it-1}$)* | | | -3.755** (2.27) | | | | | |
| *square *lagged inefficiency ($d_{it-1}$)* | | | 7.604** (2.20) | | | | | |
| lag Mkt concentration | | 0.739*** (3.44) | | 1.399*** (4.34) | | 0.196 (0.58) | | 1.127** (2.46) |
| *square* | | -0.916* (1.92) | | -1.563*** (2.97) | | -0.641 (1.51) | | -0.827 (1.31) |
| ** lagged inefficiency ($d_{it-1}$)* | | | | -1.515*** (2.85) | | | | |
| *square *lagged inefficiency ($d_{it-1}$)* | | | | 1.638** (2.09) | | | | |
| lagged inefficiency ($d_{it-1}$) | | | -1.143*** (9.72) | -1.006*** (8.00) | | | | |
| Constant | 0.005 (0.10) | -0.062 (1.03) | 0.546*** (6.64) | 0.417*** (4.35) | -0.434*** (3.28) | -0.439*** (3.02) | 0.499*** (5.00) | 0.369*** (3.22) |
| Observations | 7156 | 7156 | 6985 | 6985 | 706 | 706 | 1168 | 1168 |
| R-squared | 0.03 | 0.04 | 0.31 | 0.31 | 0.19 | 0.19 | 0.17 | 0.19 |

t-statistic in parentheses; *** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level. Robust errors adjusted for clustering at 3-digit level in regressions (1)-(4) and to two digit level, due to smaller number of observations, in regressions (5)-(8). Year and industry dummies at 2 digit level. Base year: 1996

Table A2.3. The impact of competition of firm productivity using CRS_OP productivity

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | All firms | All firms | All firms | All firms | Low Prod | Low Prod | High Prod | High Prod |
| lag Tariff rates | -0.016* (1.87) | -0.015* (1.77) | -0.053*** (3.29) | -0.049*** (3.11) | -0.018 (0.88) | -0.019 (0.89) | -0.059*** (4.75) | -0.057*** (4.26) |
| *square* | 0.001* (1.70) | 0.000 (1.60) | 0.002*** (3.54) | 0.002*** (3.26) | 0.001 (0.75) | 0.001 (0.77) | 0.002*** (4.74) | 0.002*** (4.30) |
| ** lagged inefficiency ($d_{it-1}$)* | | | 0.062** (2.37) | 0.056** (2.18) | | | | |
| *square *lagged inefficiency ($d_{it-1}$)* | | | -0.002*** (2.70) | -0.002** (2.43) | | | | |
| lag Herfindal | 1.123 (1.56) | | 2.220** (2.28) | | -0.422 (0.31) | | 4.293 (1.66) | |
| *square* | -4.408** (2.20) | | -6.951** (2.39) | | -0.892 (0.25) | | -20.721 (1.66) | |
| ** lagged inefficiency ($d_{it-1}$)* | | | -2.773* (1.74) | | | | | |
| *square *lagged inefficiency ($d_{it-1}$)* | | | 6.475 (1.58) | | | | | |
| lag Mkt concentration | | 0.508** (2.34) | | 1.033*** (2.96) | | -0.201 (0.61) | | 0.477 (0.83) |
| *square* | | -0.756 (1.66) | | -1.299** (2.18) | | 0.066 (0.14) | | -0.080 (0.09) |
| ** lagged inefficiency ($d_{it-1}$)* | | | | -1.188** (1.99) | | | | |
| *square *lagged inefficiency ($d_{it-1}$)* | | | | 1.291 (1.21) | | | | |
| lagged inefficiency ($d_{it-1}$) | | | -1.119*** (8.03) | -1.010*** (6.76) | | | | |
| Constant | -0.090* (1.68) | -0.132** (2.11) | 0.449*** (4.43) | 0.355*** (3.11) | -0.497*** (3.61) | -0.474*** (3.20) | 0.454*** (5.89) | 0.410*** (3.83) |
| Observations | 7156 | 7156 | 6985 | 6985 | 669 | 669 | 1052 | 1052 |
| R-squared | 0.03 | 0.03 | 0.31 | 0.31 | 0.18 | 0.18 | 0.15 | 0.15 |

t-statistic in parentheses; *** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level. Robust errors adjusted for clustering at 3-digit level in regressions (1)-(4) and to two digit level, due to smaller number of observations, in regressions (5)-(8). Year and industry dummies at 2 digit level. Base year: 1996