Trade Induced Factor Reallocations and Productivity Improvements

Béla Személy*

Abstract

In this paper, I measure to what extent international trade affects factor reallocations and through it aggregate productivity, using firm level data from the Hungarian manufacturing sector for the period 1992-2002. First, I quantify in what way factor reallocations influence aggregate productivity by decomposing the productivity growth index into its components: firms' own productivity increase and changes in the share of firms' value added in the industry. Then, I look at how the increase in competition, coming from trade liberalization, influences the evolution of aggregate productivity growth and its components. The results confirm the productivity enhancing effect of international competition, a 10% increase in international competition leads to a 16% increase in the aggregate productivity, where about 80% of the improvements are coming from factor reallocations.

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Contents

1 Introduction

What are the effects of trade on economic development? Ever since Ricardo proposed his theory of comparative advantage, many economists argued that there are gains from trade for both countries involved (see for example Edwards (1998)), yet measuring these gains is still a matter of controversy. A large number of empirical studies using mostly cross - country, aggregate data focused on the relationship between openness and growth, providing tentative evidence that greater openness is associated with higher growth. These studies, however, were criticized by Rodriguez and Rodrik (2000)[1], who demonstrate that the results are all sensitive to different specifications and/or time horizons. The biggest problem seems to be related to the fact that, using aggregate data, it is very hard to disentangle the effects of trade liberalization from other government policies such as exchange rate policy, taxation and subsidies, regulatory system, etc., and thus, it is hard to provide robust evidence for any of these policies' effect on growth. The debate over the pros and cons of free trade could not yet be settled perhaps exactly because of the focus was on correlations and not causality and mechanisms about how trade affects economic activity.

With the increased availability of large longitudinal micro level data sets, it is now possible to focus on the exact mechanisms of how trade might affect economic development, for example the effect of trade on productivity and factor reallocations (for a literature review of empirical studies on developing countries see Tybout (2000)). The idea is that opening up to trade induces a selection process by increasing the threshold productivity level above which firms can operate. Moreover, the higher productivity level leads to a reshuffling of the factors of production causing inter- and intra-industry reallocations (see the theoretical papers by Bernard, Eaton, Jensen and Kortum (2003), Melitz (2003), and Bernard, Redding and Schott (2004)). On the empirical side, important methodological contributions by Olley and Pakes (1996), Levinsohn and Petrin (2003), and Petrin and Levinsohn (2004) made possible the emergence of an appropriate framework in which to analyze these trade induced effects on aggregate productivity.

[1] See also the literature review in Baldwin (2003)

In this paper I will quantify the effects of factor reallocation on aggregate productivity and how trade liberalization might have contributed to it, using firm level data from Hungary, for the period 1992-2002. My choice of Hungary was determined because of, at least two reasons. First, Hungary represents a case of natural experiment, being a country that evolved from a planned economy to a market oriented one. Second, Hungary was a leading reformer among the transitional countries of Central and Eastern Europe and former Soviet Union countries, and as such, the transformation of the economy was in a more advanced stage compared to the other transitional countries[2]. Basic statistics regarding the manufacturing sector reveal that during the period of focus, from the base year 1992, the sector's value added increased to 173.8%, even though its share remained at around 25% of GDP[3].

In order to assess the effects of trade liberalization, I first calculate firm level productivity indexes, which then I aggregate to 2 digit industry levels to form aggregate industry productivity indexes. Now, I can decompose the aggregate industry productivities in two effects. First, I can measure how much of the growth is coming from individual firms' growth, holding their share in the industry constant, and second, from a compositional effect, holding the firms' productivity constant, whether more productive firms increased their share in the industry. Also, I am able to distinguish between the productivity effects coming from new, entering firms and exiting ones as well. The hypothesis investigated in this paper is that trade liberalization has an important effect on the exit rate of firms and also on the much broader reallocation term. The intuition behind this is that higher competition will force less productive firms to exit the market, and as such, to cause the reallocation of resources towards more productive firms.

The paper is organized as follows. In Section 2 I present a brief discussion of the related literature. Section 3 contains the methodology concerning the estimation of plant and industry level total factor productivity. First, I discuss how the production function parameters are estimated and how the firm level productivity levels are calculated. Then, I proceed with the methodology concerning the calculation of aggregate industry productivity indexes and aggregate industry

[2] See European Bank for Reconstructin and Development (1999)

[3] See Hungarian Central Statistics Office (2002)

productivity decompositions. Finally, I discuss the methodology concerning the estimation of the effect of international trade on aggregate productivity, and on its components. In Section 4 I describe the data that will be used to assess the effect of international competition. Section 5 contains the results of the present study. The final section concludes.

2 Related literature

Starting from the early '90s a large literature evolved in analyzing the effects of international trade on economic activity by using firm or plant level data (see the literature review by Tybout (2002)). This turn was initiated by at least two motives. The first motive resulted from the heated policy debates about the pros and cons of free trad in the U.S., especially after signing the NAFTA and GATT agreements. Another important motivation for this burgeoning literature was the renewed interest in understanding *how* trade affects economic development. From a bird's eye view, the benefits of free trade were all too obvious by comparing the experience of the export oriented Asian economies with the inward oriented, protectionist Latin American countries. However, it was, and still is, not clear through which mechanisms trade benefits economic development. Thus, a closer look was needed at a more disaggregated level. The mechanism that were mostly investigated in the literature are[4]: the nature of exporting firms compared to non-exporting ones, the importance of technological transfers through FDI, and the effects of increased competition on factor reallocation.

The first strand of literature focused on the characteristics of exporters compared to the firms/plants that operated in non-traded sectors. For example Bernard and Jensen (1995) provide evidence for significant differences in U.S., that is exporting firms are larger, more productive, more capital intensive, and pay higher wages compared to non-exporting ones. However, the role of trade is not yet clear, since the issue at stake is: is exporting beneficial for firms, or the causality runs form the highly productive firms towards exporting? The benefits to the firm could be many: by participating in the export market, firms could diversify their product market, get access to improved technology, produce spill-over effects, exhibit characteristics of learning-by-exporting, etc. The latter is precisely the question being asked in Clerides, Lach and Tybout (1998): is learning by exporting important for firms? They first build a theoretical framework in which to analyze the implications when exporting firms exhibit learning-by-exporting behavior, and then proceed with testing it, to analyze the extent to which this phenomenon is happening in Colom-

[4]This is of course not a comprehensive list of issues investigated, one cannot do justice to all the aspect analyzed, the literature mentioned above only intends to provide an overview about some of the most important issues that arise with trade liberalization. This chapter also draws on Antràs (2005)

bia, Mexico, and Morocco. As it turns out, they find scant evidence for learning-by-exporting and show that the reason why exporting firms are more productive then non-exporting ones is mostly due to self-selection. Their conclusion is also reinforced in Bernard and Jensen (1999) using plant level data from the manufacturing industry in the US.

The findings of this literature are quite relevant to the topic of this paper. If exporting does not contribute to individual firms' productivity growth then it also does not cause any other spillover effects to the domestic firms. In conclusion, it might not be exporting through which the domestic sector is affected by international trade. The other facet of trade liberalization is opening up of domestic markets to foreign goods. This can result in higher competition in the products market, either through imports or through goods produced by foreign entities in the country. Before turning to the market disciplining effect of higher competition, it is important to realize that foreign investments may affect domestic firms in many other important ways. The most important effects, which were discussed in the literature are technological diffusion, skill transfers, or increased demand for intermediate inputs from domestic suppliers. This is the area of research which I next discuss.

The presence of foreign companies in the domestic market has been considered to have significant effects on domestic firms. The main beneficial effects were thought to be technological spill-overs to the domestic firms and increased demand for the suppliers of intermediate goods to the multinationals. Turning to the former issue, Aitken and Harrison (1999) looks at firm level data in Venezuela for the period 1976-1982, and try to quantify the extent to which domestic producers benefited from the foreign presence that is, whether their productivity increased with the presence of foreign firms. What they find is actually quite intriguing, their results show that the productivity of domestic producers actually declined with the increase of foreign direct investment (FDI) in that sector. This suggests that very little, if any, technological diffusion is taking place in the industry where FDI flows in.

Other spill-over effects may also result from FDI, mainly through the way of local suppliers to the multinational companies. One way domestic suppliers might benefit from the presence of multinationals is from increased demand for intermediate inputs. Multinationals might also give technical assistance to their suppliers, in order to receive higher quality intermediate goods. These issues are investigated in Smarzynska (2004), who looks at these backward linkages effects in Lithuania between 1996-2000. Her results provide evidence for the above mentioned spill-over effect, Smarzynska (2004) estimates that a 10% increase of FDI in a sector, leads to 0.38% rise in the output of the supplying industry.

The results from the above papers point to the following conclusions: first, trade liberalization does not cause existing exporters to become more productive, instead, firms self-select themselves into exporting. This means that only already productive enough firms will export abroad. Second, the presence of foreign firms in the domestic market might not result in spill-over effects to their competitors, however suppliers of the foreign companies do benefit from increased demand for intermediate goods and technical assistance from the multinationals. The third effect that comes with trade liberalization is the market disciplining effect of competition coming from abroad. Intuitively, increased competition will induce less efficient domestic firms to exit the market, thus contributing to the increase in the aggregate productivity. The freed factors of productions, labor and capital, can now be reemployed more efficiently, reinforcing the growth of the sector as a whole[5]. This is the mechanism that the present paper intends to look at. Existing research has little to say about the effects of trade on exit and productivity enhancing effects of factor reallocations, with some notable exceptions to which I now turn to.

The aggregate effects of factor reallocations have been widely discussed in the literature[6]. One piece of evidence, which is coming from the trade literature, is by Bernard and Jensen (2005), who investigate continuing manufacturing plants in the US, over the period 1983-1992. Their results confirm the major effect of factor reallocations on aggregate productivity, they estimate that, even in such a developed country, around 40% of the aggregate productivity growth stems

[5]As early as 1942 Joseph Schumpeter (Schumpeter 1942) pointed to the *Creative Destruction* effects of competition.

[6]See also the literature review in Foster, Haltiwanger and Krizan (2001).

from factor reallocations. Moreover, they distinguish between inter- and intr-industry reallocations and find that both types of reallocations are important for the aggregate productivity. They estimate that half of reallocations occur within industry and that reallocations are mostly towards exporting firms.

An important study concerning the determinants of these factor reallocations is by Pavcnik (2002). Pavcnik studies the effect of trade liberalization that occurred in Chile from the end of 1970s. She uses plant level data for the period 1979-1986 and explores the consequences of trade liberalization by comparing traded (import competing and export oriented) and non-traded sectors over time. This difference in difference approach yields her important results, specifically, the increased competition, on average, raises the productivity of firms operating in import competing sectors. This productivity difference is found to be ranging from 2.4% to as high as 10.1% depending on the year in question. Also, Pavcnik (2002) finds that exiting firms are less productive than surviving firms. However, quite intriguingly, this difference in productivity does not depend, whether the exiting firms belong to an import competing sector or a non-traded one. Overall, Pavcnik (2002) estimates that aggregate productivity growth increased more in industries that were exposed to international trade, and the induced factor reallocations contributed to about 70% of the overall 2.8% growth in the manufacturing sector's productivity evolution.

Of the few papers that investigate the productivity enhancing effects of factor reallocations in the transitional economies are the papers by Brown and Earle (2002), and Brown and Earle (2004). In Brown and Earle (2002) the productivity enhancing effects of inter-, as well as intra-sectoral factor reallocations are investigated using firm level data for Ukraine and Russia. Their results provide evidence for the major importance of factor reallocations to productivity growth, and to the differential evolution of the Ukrainian and Russian economy. Interestingly, Brown and Earle (2002) find that the affect of factor reallocations was more pronounced in the first part of transition. Turning to the determinants of these factor reallocation, Brown and Earle (2002) estimate that competition in the product markets (which is of concern for this paper) did influence the inter-sectoral factor reallocations in both countries during the first part of transition. However, its significance declined in the latter period, being only marginally significant in Russia and only for intra-sectoral factor reallocations.

In Brown and Earle (2004) the determinants of factor reallocations were complemented with the effects coming from international competition as well. The authors' interesting finding is that competition coming from abroad, measured by the import penetration ratio, was not a significant determinant of productivity enhancing factor reallocations. A possible reason for this insignificant effect may be that both Russia and Ukraine, throughout the period, maintained significant restrictions to trade[7].

The case of Hungary is different in many aspects from the countries analyzed above[8]. Hungary was a frontrunner in the adoption of reforms concerning liberalization, privatization, and other areas as well, and at the same time Hungary was also the recipient of one of the highest foreign direct investment per capita in the region. Thus, because of the major structural change, and because of the pace of implementing reforms, Hungary might rightly be considered a good case of natural experiment, quite suitable for analyzing the effects of trade liberalization. This is also the reason why I choose to work with data from Hungary. Even though my data covers only the period after 1992, I expect to find significant evidence concerning the productivity enhancing role of factor reallocations. Also, increased competition coming along trade liberalization is expected to contribute to factor reallocations by forcing less productive firms to exit, and as such, letting these resources to be reallocated in more productive enterprizes. In the next section I turn to aspects related to the methodology that will be used in the paper.

[7]See Worlbank (2002)

[8]For a comparison of the evolution of different countries during the transition period, see Worlbank (2002).

3 Methodology

In this section, I present the methodology that will be used to calculate firm level total factor productivity indices[9], and to how to aggregate the firm level productivities into an industry productivity index. Also, different decomposition methods of aggregate productivity are presented to evaluate from where the growth is coming from: individual firms' productivity growth or growth stemming from factor reallocation. Finally, I present the methodology concerning the estimation of international trade on the aggregate productivity growth and its components.

3.1 Firm level productivity

To estimate the firm level productivity I start with the following production function[10]:

$$y_t = \alpha_0 + \alpha_1 l_t + \alpha_2 k_t + \alpha_3 m_t + \epsilon_t \tag{1}$$

where y_t is the logarithm of the value added, l_t, k_t, and m_t are the logs of labor, capital, and material inputs of the firm at time t, and ϵ_t is a disturbance term. The parameters of the production function can be estimated consistently by OLS if there is no contemporaneous correlation between the inputs and the disturbance term. This, of course, presumes that the inputs are chosen exogenously. However, there is reason to believe that firms adjust their inputs according to their beliefs and expectations[11]. In this case the parameter estimates will be biased.[12]

To get around this problem Olley and Pakes (1996) devise a new methodology, that is they decompose the disturbance term into a state dependent and an i.i.d. component. The trick they use here is the assumption that the state dependent component affects the firms' decision rules, while the i.i.d. component does not. To provide an intuition for this assumption, one can think

[9]From now on the terms productivity, total factor productivity and TFP will be interchangeably used

[10]The above production function can be regarded as a first-order approximation of a general production function or the exact one if Cobb-Douglas technology is assumed.

[11]For a discussion about the problems of estimation of production functions when using a panel of micro level data for plants or firms, see Griliches and Mairesse (1995).

[12]Another problem is related to the use of deflated sales as proxy for output. As was shown in Klette and Griliches (1996) and Melitz (2000) in case of imperfect competition and price dispersion, the estimated elasticities are biased. However, the present paper does not deal with this issue.

of the state dependent disturbance term as representing the productivity term that is known to the firm, but it is not known to the researcher. Consequently, the i.i.d component of the disturbance term can be interpreted as different unanticipated demand and/or supply shocks occurring during the period of production. Following Levinsohn and Petrin (2003) one can write (1) in the following way

$$y_t = \alpha_0 + \alpha_1 l_t + \alpha_2 k_t + \alpha_3 m_t + \omega_t + \eta_t \tag{2}$$

where η_t is the i.i.d. component of the disturbance term, and ω_t is the state dependent unobserved productivity. Labor is assumed to be a variable input, while capital is a state variable. Demand for the intermediate inputs is assumed to be a function of capital and the state dependent productivity term:

$$m_t = m_t(k_t, \omega_t)$$

In case when this demand function is monotonically increasing in ω_t, one can express ω_t by inverting the intermediate inputs demand function:

$$\omega_t = \omega_t(k_t, m_t) \tag{3}$$

In this case, the unobservable productivity is expressed in terms of observable variables. One more assumptions is required for the identification of the parameters of the production function. Levinsohn and Petrin (2003) assume that ω_t follows a first order Markov process:

$$\omega_t = E[\omega_t|\omega_{t-1}] + \xi_t \tag{4}$$

where ξ_t is an innovation to productivity that is uncorrelated with k_t. This is basically the Olley and Pakes (1996) framework using intermediate inputs instead of investments[13]. With this model in hand, one can consistently estimate the parameters of the production function (1) even in case of simultaneity between the disturbance term and the inputs of the production function. The estimation procedure uses the Levinsohn - Petrin routine, the description of which is relegated to Appendix.

[13]For a discussion of the two methods see Ackerberg and Caves (2003)

3.2 From firm level productivity to aggregate industry productivity

Since total factor productivity was first developed from aggregate and industry level data[14], the link between firm or plant level productivity and aggregate industry productivity is not an obvious one. To show this, consider the following definition of the aggregate industry productivity (I_t):

$$I_t = \sum_{i=1}^{N} s_{it} P_{it} \tag{5}$$

that is, the aggregate industry productivity is a weighted share(s_{it}) of the individual firm level productivities (P_{it})[15]. The traditional approach used for weights was the output share of each firm in the industry. However, as was noted in Foster et al. (2001), output share is not independent of the productivity index thus, they propose for weighting the firm level productivities by their input shares. Interestingly, the same criticism can also be applied for the input shares, that is inputs are chosen also according to the firms' productivity levels and such inputs are also endogenous. For this reason, Petrin and Levinsohn (2004) argue for the use of the firm's share in the real value added of the industry as the correct weight. They also provide a theoretical background for the use of value added as weight, by connecting the productivity framework to the growth accounting one. I will follow up on their suggestion and use value added as weights for the firms' share in the industry.

More problems lurk in the background when one tries to calculate the industry productivity growth. For example, take the most commonly used measure of industry productivity change, the one suggested by Baily, Hulten and Campbell (1992). This index is measured as

$$\sum_i s_{it} P_{it} - \sum_i s_{it-1} P_{it-1} \tag{6}$$

Now, consider the discrete time approximation of the instantaneous productivity growth. For such an approximation the Tornquist approach has been the most commonly approach used in

[14]For a thoughtful discussion of the history of the residual see Hulten (2001).

[15]Firm level productivities are calculated as was discussed in the previous section.

the literature[16]. Thus, in this case the aggregate productivity growth is given by

$$dP_i \approx \sum \frac{(s_{it} + s_{it-1})}{2} \Delta P_{it} \tag{7}$$

Comparing (6) and (7) Petrin and Levinsohn (2004) indicate that the appropriate industry productivity growth is given by (7) and not (6) and that (6) contains, incorrectly so they argue, an additional term, a term which is often referred to as a reallocation effect.

To assess the difference between the two growth rates Petrin and Levinsohn (2004) show, by using Chilean and Columbian plant level data, that (6) and (7) differ by several orders of magnitude, more specifically (6) overstates (7). However, in case of Hungary the two productivity growth rates produce almost the same results, thus I will adopt the definition of productivity growth as defined in (6).

3.3 Aggregate industry productivity decomposition

In this section I will discuss different methods to decompose the aggregate industry productivity. I will start with the favorite decomposition method, which is a refinement of the original decomposition proposed by Baily et al. (1992)[17]. This method decomposes the aggregate industry productivity growth in the following parts:

$$\Delta I_t = \sum_{i \in C} s_{it-1} \Delta P_{it} + \sum_{i \in C} (P_{it} - I_{t-1}) \Delta s_{it} + \sum_{i \in N} s_{it} (P_{it} - I_{t-1}) - \sum_{i \in X} s_{it-1} (P_{it-1} - I_{t-1}) \tag{8}$$

where s denotes the share of the firm's value added in the total industry value added, P is the firm level TFP, I is the industry productivity index, C denotes the set of continuing plants, N the set of entrants, and X the set of plants that exit in the year. The four components distinguished are the following ones: (i) the within firm effect - within firm growth weighted by the initial value added shares; (ii) reallocations at continuing firms - relates to the change in the firms' value added share weighted by the deviation of the end period firm level productivity from the

[16] See Hulten (2001).

[17] For an overview of these decomposition methods and for a literature review using these decompositions see the paper by Foster et al. (2001).

initial period industry TFP; (iii) entry effect - year end share weighted sum of the difference between the TFP of entering plants and initial industry productivity; (iv) exit effect - initial share weighted sum of the difference between exiting firm's TFP and initial industry productivity.

The interpretation of the terms that contain the industry TFP is the following: for continuing firms, increasing its share in the industry will result in an increase in the aggregate productivity only if its initial TFP is higher than the industry TFP. Entering firms contribute to the aggregate productivity only if they have higher TFP than the initial aggregate productivity. Exiting firms contribute to the aggregate productivity when their productivity is below the initial industry productivity.

The difference of this decomposition from the Foster et al. (2001) suggested one is minimal, yet is still an important one. It is easy to see that the second term can be decomposed into the following two terms, thus resulting the Foster et al. (2001) proposed decomposition:

$$\sum_{i \in C}(P_{it} - I_{t-1})\Delta s_{it} = \sum_{i \in C}(P_{it-1} - I_{t-1})\Delta s_{it} + \sum_{i \in C}\Delta s_{it}\Delta P_{it} \tag{9}$$

where the first term is the change in the value added shares weighted with the deviation of the initial firm level TFP from the initial aggregate one, and the second term is a covariance term: the product between the change in the value added share and firm's TFP change. The first term of this decomposition is sometimes referred to as between-firm or reallocation term. A problem might arise from the fact that one can easily come up with examples where the first term of this decomposition will not capture any reallocation, yet by construction, reallocations happen[18].

Another note to this decomposition is related to the endogenous nature of factor reallocations. If reallocations are endogenous then without productivity change, reallocations might not happen

[18]For example consider an industry with two firms (A,B) operating in two periods. Both firms in period one have productivities equal 1 with shares 0.5. In the second period firm A's productivity remains 1 but its share decreases to 0.4, while the second firm's both productivity and share increases to 1.2, respective 0.6. In this case clearly reallocation happens, however the reallocation term in Foster et al. (2001) decomposition will not pick up anything.

at all[19]. As a consequence it might be misleading to interpret the first term from the decomposition (9) as measuring the effect of reallocations if the firms' productivity would have remained constant. This motivated the use of the little modified version of the original decomposition method proposed by Baily et al. (1992).

Another method of decomposition is due to Olley and Pakes (1996) who, instead of decomposing the industry productivity growth into several of its components, look at the composition of the sectoral productivity. The reason for this is that they want to see what part of the industry productivity is coming from activity located disproportionately at high productivity firms. Their cross-sectional decomposition is as follows:

$$I_t = \overline{I_t} + \sum_i (s_{it} - \overline{s_t})(P_{it} - \overline{I_t}) \tag{10}$$

where the bar over the variables denote the arithmetic average of the variables in question. The easiest way to think about this term is to realize that, it is only the difference between the weighted average and arithmetic average productivity of the industry. It should be noted that this term can also take negative value, in which case it means that the bulk of aggregate productivity is coming disproportionately from firms with lower than average productivity. When implementing this decomposition, I will normalize these variables with the aggregate productivity index, calculated as a weighted average of individual firm TFPs. The covariance term can now be interpreted as what proportion of aggregate productivity is coming from activity located at high productivity firms. The change in the covariance term is a reflection of the compositional shifts, reallocations, in the sector.

In Section 5.1 I will provide results for all three productivity decomposition methods, to assess the effect of reallocations on aggregate industry productivity.

[19] See for example the theoretical papers by Hopenhayn (1992) and Ericson and Pakes (1995). In Hopenhayn (1992) unknown productivity shocks to the firms drive reallocations, while in Ericson and Pakes (1995) the uncertain outcome of investments projects is needed for reallocations to happen.

3.4 The effect of trade on productivity dynamics

Up until now, I presented the methodology about how to calculate firm level productivity, aggregate industry productivity, and also, how to decompose the aggregate industry productivity to its separate parts. In this section, I present the methodology concerning the estimation of the effects of trade on the aggregate productivity and its components.

To proceed, I modify the decomposition method (8) in the following way:

$$\Delta I_t = \sum_{i \in C} s_{it-1} \Delta P_{it} + \sum_{i \in C} P_{it} \Delta s_{it} + \sum_{i \in N} s_{it} P_{it} - \sum_{i \in X} s_{it-1} P_{it-1} \tag{11}$$

where the terms are similar to (8), the difference is coming from the missing initial aggregate productivity terms. This decomposition is actually the original method proposed by Baily et al. (1992). The reason for taking out the initial aggregate productivity terms from the original decomposition (8) is very simple. If trade affects both industry productivity and the reallocations at continuous firms, then by having the difference of these two terms regressed on a trade proxy, the coefficient might turn out to be insignificantly different from null.

I am specifically interested in the term that represents the contribution of exiting firms to the aggregate productivity dynamics and in the broadly defined reallocation term. For notational purposes, I define this reallocation term as the sum of the effects coming from reallocations among continuous firms and net entry effects:

$$R = \sum_{i \in C} P_{it} \Delta s_{it} + \sum_{i \in N} s_{it} P_{it} - \sum_{i \in X} s_{it-1} P_{it-1} \tag{12}$$

With these modifications in hand, I specify the following regression:

$$y_{it} = \alpha_i + T_t + \beta \Delta impp_{it} + \gamma X_{it} + \epsilon_{it} \tag{13}$$

where y_{it} will take on in turn, industry i productivity growth at time t, within firm effect, between firms effect, entry, exit, and, finally, the reallocation term (R). The main right-hand-side variable will be the import penetration ratio. The definition of the import penetration ratio ($impp$) for a given industry is: the share of the imported goods in total goods present on the market ($impp = imports/(output + imports - exports)$). This ratio will be used as a proxy for the intensity of the international competition. The main parameter of interest in equation (13) is β. The need to include a control variable X_{it} is arising from the fact that the import penetration ratio is an endogenous variable. Thus, with X_{it} I will control for other effects arising with trade liberalization, effects that have an influence both on the import penetration ratio and industry productivity. Equation (13) has also incorporated industry fixed (α_i) and time effects (T_t), to control for industry specific effects and various macroeconomic shocks in different years.

The next section presents the data that will be used later in the paper. I will now turn to the description of it.

4 Data

The database used in this paper comprises a substantial sample of firms operating in the Manufacturing sector in Hungary and contains data from the year-end financial reports of these firms to the Hungarian Tax Authority between 1992-2002. It must be emphasized that, I observe only firm level data, and not plant level one. This lack of disaggregation must be kept in mind when discussing the results.

The data underwent an extensive cleaning procedure, also with respect to the continuity of the firms in the panel. By using a database provided by the Hungarian Statistical Agency, I identified links between different exiting / entering firms in subsequent years, so that to have a cleaner assessment of continuous firms, mergers, split-ups and spin-offs that happened throughout this period. This step was a crucial part, since entry / exit of firms represent an important aspect for the research question raised in this paper. If among the exiting firms there are also included cases like mergers or acquisitions, exits which need not be related to market selection, then the resulting estimate does not provide an accurate magnitude for the selection process.

From the total number of firms, I selected only firms where the number of employees exceeds 5 people. This truncation is a result of the fact that these small firms do not have complete data. I also drop those firms that have missing data on labor, material costs, or fixed assets, and also those firms that have missing data in-between years. In total, I remain with an unbalanced panel of 79812 observations. Table 1 presents the total number of firms by year and the number of firms that remained in the panel for a total of 11,10, 9,... years. As can be seen from Table 1, only 1376 firms, less then 10% of all firms, remain in the panel throughout the studied period, a fact that points to the tremendous churning that went on in this first decade of transition.

Table 2 presents the descriptive statistics of the variables in question. The variables to be used are the following: gross revenue; valued added is calculated as gross revenue net of material costs; labor is the number of employees at a firm; I use fixed assets as proxy for capital; and materials representing gross material costs. I deflate all variables, less employment, with two digit industry deflators to have all the variables expressed in constant 1992 million forints. By the change of the import penetration ratio, I measure the change in the competition resulting from trade liberalization. Next, I turn to the section containing the results.

5 Results

In this section I present the results concerning the estimation of production function parameters and the calculation of productivity indexes. After estimating firm level productivities, I calculate aggregate industry productivity growth indices, which I can then decompose into its parts according to Section 3.3. These results are presented in the next subsection. In Section 5.2, I turn to the estimation of the effect of international competition on industry productivity growth and its components. Specifically, I am interested in the aggregate effect of the selection mechanism, and how trade interacts with this process. The estimation results are presented in Section 5.2.

5.1 Productivity dynamics

In this section I present the results concerning firm level productivity indices, aggregate industry productivity growth rates and the resulting decompositions. First, I estimate the individual firm level production functions, by clustering firms into 2 digit level industries and using the Levinsohn-Petrin routine. Then, following the methodology outlined in Section 3.2, I calculate aggregate industry productivity growth rates.

Table 3 presents the yearly overall aggregate productivity improvements for the period 1992-2002. In the table all the growth rates are expressed compared to the base year 1992. As Table 3 reveals, during the years 1992-2002 the aggregate productivity in the manufacturing sector more than doubled (an increase of 108%), a result that is not hard to believe considering the major restructuring process that has happened during the transformation of the economy from a socialist to a market oriented one. When one looks at the yearly average productivity growth of around 7.7%, it has to remember that throughout the period Hungary was considered one of the most advanced country among the transitional ones in reforming its economy[20]. In light of this, the 7.7% productivity growth seems quite plausible.

Next, I turn to the components of the productivity growth indices to understand where the

[20] See Worlbank (2002)

growth was coming from during the period analyzed. The decomposition methods used were the slightly modified decomposition proposed by Baily et al. (1992), and the newer method coming from Foster et al. (2001). Table 4 presents the results concerning the components of the aggregate productivity growth. The results in Table 4 provide evidence for the important productivity enhancing role played throughout this period by factor reallocations. On average, more than 80% of the aggregate productivity growth was coming from factor reallocations. When compared to the other findings in the literature, the 40% obtained for the US in Bernard and Jensen (2005) pales away. The result is more close to the findings of Pavcnik (2002), who finds that 70% percent of aggregate productivity growth is coming from factor reallocations. The difference however to Pavcnik (2002) is that while she found that on average the aggregate productivity in Chile grew by 2.8%, here the yearly aggregate productivity improvement was 7.7%.

Looking at the results term by term, we can notice that the 1.48% productivity growth at the firm level is right in line with the findings of Bernard and Jensen (2005), who report 1.42% individual firm productivity growth. When looking to the reallocations happening between the continuing firms, the overall picture shows that, holding the firms' end period productivity constant, the change in the firms' share in the industry value added contributed to the aggregate growth by 6.91%. When we decompose this figure, column (4) and (5) of Table 4, we see that, holding the firms' initial productivity constant, factor reallocations would have decreased the aggregate productivity growth with 5.88%. However, considering the endogenous nature of factor reallocations it is perhaps misleading this interpretation. If there would not have been productivity changes factor reallocations perhaps would not have happened. The covariance term can be interpreted as the contribution of those firms whose both productivity and share in the industry changed in subsequent periods. The fact that this term is positive shows clearly the productivity enhancing nature of reallocations, which contributed with a massive 12.79% to the aggregate productivity growth.

Turning to the nature of new, entering firms, the results reveal that these firms are on average less productive than the initial aggregate industry productivity. This might reflect high initial sunk costs, initial investments, etc. The exiting firms productivity level is below the initial period's aggregate productivity and, as such, seems to confirm the selection mechanism: on average, those firms exit the market that have lower than average productivity. However, among these exiting firms there are also ones that merged or were brought out by more productive firms and thus not related to the selection process. This might results in a misleading picture of the true exiting firms' average productivity. Thus, I calculated the average productivity of those firms which were actually classified as exiting. The results improved, although it turned out to be a relatively small productivity difference as well. Exiting firms had -0.2% lower productivity than the industry productivity. These estimates, however, should be taken only as being informative and should not be regarded as conclusive. Averaging over years and sectors, produces results that are subject to measurement error issues, while different weights might produce different results. In conclusion, it seems that the the big chunk of the productivity gain lies in the expansion of continuing, above average productivity firms.

Next, I turn to the Olley-Pakes decomposition method. Table 5 presents the results for the whole period, that is how much of the aggregate productivity is coming from firms located disproportionately at the upper tail of the productivity distribution. Table 5 reveals the average composition of the productivity in an industry, in which the productivity distribution is heavily skewed towards the high end. On average, 70% of the weighted average is coming from firms with productivities higher than the arithmetic average productivity of the industry. The year to year changes of this term can be interpreted as a factor reallocation process. Next, I will investigate the determinants of factor reallocations with their consequences on aggregate productivity.

5.2 The effect of trade on productivity dynamics

Since, as we have seen in the previous section, reallocation is a major factor in the evolution of the aggregate productivity, it is important to understand what are the causes of these factor reallocation. Thus, I arrive to my major question, what is the role of international trade in this process? Specifically, I ask what is the aggregate effect of international competition, as measured by the *import penetration ratio*, on the domestic economy. To answer this question I will use sectoral data at 2 digit level and estimate how the aggregate industry productivity growth and its components depend on the import penetration ratio.

The results are presented in Table 6. Considering specification (1), the estimated effect of an increase in the change of the import penetration ratio by 10%, causes a whooping 16% increase in the aggregate industry productivity growth. This suggests that due to higher international competition, domestic industries, on average, become more productive. As Table 2 shows the mean of the change in the import penetration variable is 1.4%, so perhaps it is better to consider a 1% change, which then causes a 1.6% improvement in aggregate industry productivity. However, as Table 2 reveals, during this period in, the import penetration ratio had leaps even as high as 30.6%., thus rendering 10% changes as a real possibility.

Through what channel did this productivity growth come by? On the one hand, as specification (2) clearly shows, the mechanism was not that individual firms became more productive. The estimated impact of higher competition on continuing firms is statistically non-significant. On the other hand, as specification (6) suggests, the efficiency gains are realized through factor reallocations: a 10% increase in the import penetration ratios increases the productivity enhancing effect of factor reallocation by as much as 21%.

Looking at the components of the reallocation term it can be seen that most of the efficiency gains are realized through the expansion of the relatively more productive firms. As the results from specification (4) suggest, the increased competition affected in a significant manner the new firms, by reducing their productivity. This means that new firms entered into a more and more competitive environment. However, the interpretation of this finding is not clear. Since entry is usually associated with innovative activity, it can be that entering firms have high investments in the first year, perhaps even sunk costs as well, thus making such an aggregate measure of productivity not easily interpretable.

Specification (5) provides further evidence for the mechanism trough which international competition is thought to affect domestic firms, that mechanism being market selection. The estimated effect of international competition can be interpreted as, an increase in the import penetration ratio causes less productive firms to exit the market. The aggregate consequence of 10% increase in the import penetration ratio is a decrease by 3.3% of the weighted average of the exiting firms. This has a positive effect on aggregate industry productivity as this terms enters with a negative sign into equation (11). The estimated effect is statistically significant at the 10% level (p value equals 5.6%).

It is also interesting to compare the two calculated exit rates: the first measure includes all the observed exits, and the second one take into account only exits that are coded as such, without exits due to mergers or acquisitions. Using the first measure as dependent variable in specification (5), the estimated coefficient turns out to be negative, but insignificant (the estimated coefficient was -0.191). The significant estimate in case when the second exit rate was used suggests the usefulness of data cleaning.

I will now turn to evaluate the sensitivity of the above findings. Starting with the choice between fixed- and random effect models, the Hausman specification test does not reject that the difference between the two coefficients is not systematic. The interpretation of this result is that, the growth rates of different industries were not industry specific, productivity growth evolved in the same way across industries. Thus, in order to gain more degrees of freedom, from now on I will use the random effects specification.

Next, I will discuss the import penetration ratio as a proxy for international competition. It is important to realize that the import penetration ratio is an endogenous variable, even though to some extent it does measure the magnitude of competition coming from abroad. For example take a country, which is importing a certain final good. Now consider a foreign firm that decides to establish a subsidiary in the home country and produces the same good for the domestic market. Other things being equal, this will cause a fall in the import penetration ratio, even though this does not mean a decrease in competition. Thus one should control for this effect to test the sensitivity of the estimated coefficient.

Because of these concerns, I introduce a variable called *Foreign Share*, which is constructed as follows: first, I define a firm foreign owned, if the majority shareholder (more than 50% of shares) in that firm is foreign. Then, I calculate a weighted average of this variable across 2 digit industries, the weights being the firms' share in the industry's value added. This variable should account for trade effects coming mostly via foreign direct investments. Also, this variable should control for the effects of foreign direct investments on the import penetration ration. This variable is then included in equation (13) to assess the robustness of the initial finding.

As can be seen from Table 7, that the now included Foreign Share variable indeed has a significant effect, even though it did not alter the basic finding: international competition is a major determinant in the factor reallocation process. On average, international competition enhances aggregate productivity growth through factor reallocation, even controlling for foreign presence in the domestic market. The estimated effect: a 10% increase in the import penetration ratio will result in a 14% productivity improvement coming only from reallocation.

With respect to the $ForeignShare$ variable, the results imply that an increase of 10% in the share of value added coming from foreign companies, will lead to an increase of almost 4.75 percentage points of the average individual firm productivity growth, the effect being a statistically significant one. The mechanism for this positive effect can be either privatization of domestic companies to foreign entities, or foreign direct investments. The negative sign of the effect of Foreign Share attributed on the factor reallocation process cannot be easily interpreted, in fact the negative sign is quite puzzling. One interpretation to this finding that can be given is that this variable might also capture the maturing of industries, as in the latter period most of structural transformations might have been over. Thus, the estimated negative effect implies that factor reallocations happen at a lower pace in matured industries than in industries where structural changes are happening.

To test for this interpretation, I rerun equation (13) on a smaller sample, covering only the years 1996-2002. The reason for doing it is that perhaps during this period factor reallocations were already less influenced by the structural changes. As it turns out, in this case the estimated coefficient was positive at 0.20, significant at 11% level. This result gives support for the initial interpretation. Also, the above result suggests that in industries where foreign firms are present reallocations contribute more to aggregate productivity.

Turning to the decomposition suggested by Olley-Pakes, I now rerun equation (13), however this time y_{it} will represent the change in the covariance term in decomposition (10). The results from Table 8 strengthens the case for productivity enhancing factor reallocations. With the increase of international competition, industry productivity is increasingly coming from firms located disproportionately at the high end of the productivity distribution. This effect is taking place even if we control for the foreign presence in the domestic market.

The above findings have also limitations that one should bear in mind before accepting these results. First, the results concerning total factor productivity estimates are quite sensitive to different methodologies, measurement errors and unobserved production components[21]. Also, it should be noted that the theoretical link between firm level productivity estimates and aggregate productivity measures is not yet forged in a convincing way. It is perhaps the biggest challenge in the productivity analysis literature to link the micro and macro measures together. Thus, the above results might also be sensitive to different weights used in aggregation, and last, but not least, on the definition of the industry productivity growth index.

The results from this paper have important policy implications. It points to the fact that trade liberalization can have large impact on domestic firms, causing inefficient, unproductive firms to exit the market. The question that now arises is what kind of policies should the government

[21] See Biesebroeck (2004)

adopt in order for the country to benefit fully from trade liberalization. One side of the question is clear: it should ease the barriers from firm turnover and let the entry and exit mechanism work properly. The more quickly can a bankrupt firm exit the market, the sooner can the freed resources, be that labor or capital, be reemployed elsewhere. Also, the easier can a new firm, be it domestic or foreign, enter the market, the quicker can the factors of production be reallocated. This is of course from the efficiency point of view.

Another consideration is that, rapid trade liberalizations might have disruptive effects, especially in the labor market. Thus the question arises: what can the government do in order for the reallocation process to run smoothly? The present paper does not provide answer to this question. As it turned out in Hungary, resources were reallocated successfully, without causing much disruptions. However it need not be this way. As a consequence the above question is important since if trade liberalization leads to large disruptions, especially in the labor market, the whole process might backfire for the political leaders. Thus future work should consider to answer to questions like: can government programs provide help in order for the labor force to reallocate towards other sectors without large disruptions? What kind of programs should the governments consider for this scope? This in an area where clearly answers are needed in order to help governments to make thoughtful decisions and to avoid backlashes against market forces and trade liberalization.

6 Conclusions

This paper looked at the effects of trade liberalization on productivity growth, arguably the most important determinant of long-run growth. The main mechanism assessed was the productivity enhancing effect of the factor reallocation process. First, I determined to what extent in Hungary aggregate productivity dynamics depended on factor reallocations. Then, I investigated in what way trade liberalization affected the aggregate productivity growth through factor reallocations. The idea investigated was that the opening up of domestic markets will result in higher competition for domestic firm. As a result of this increased competition, the less productive firms will have to exit the market. The freed resources can be thus reemployed in much more efficient and productive ways.

To assess this mechanism, the paper investigated the quasi-experiment that took place in Hungary, a country that evolved from a socialist economy to an economy driven by market forces. For this purpose, firm-level data from the manufacturing sector was used for the period 1992-2002. The paper's findings provide evidence for the productivity enhancing effects of factor reallocations. During this period, the average industry productivity growth was 7.7%, 80% of it coming from factor reshuffling. Looking at the role of international trade, the main finding was that, on average, a 10% increase in the import penetration ratio will lead to a 16% increase in the aggregate industry productivity growth. Moreover, this growth is realized through the exit of less productive firms, and the reallocation of resources toward more productive one. The results are robust even after controlling for other trade liberalization effects.

These results also point to several research directions. First, it is important to extend this analysis by incorporating inter-industry reallocation effects. Bernard and Jensen (2005) provide evidence to the relative importance of inter-industry reallocation in US. Due to the structural changes, this type of reallocation might have been even more pronounced in Hungary. Incorporating these inter-industry reallocations, one would have an estimate of the overall effect of international competition. Second, it is important to see the relative effect of trade liberalization compared the other economic policy choices, like privatization, financial sector reforms, etc., thus having a clearer picture of what is causing what, and also in what magnitude. Third, once we understand how international competition frees up inefficiently allocated resources, it is important to investigate how can these resources be again reemployed more efficiently, in such a way as to avoid the disruptive effects of factor reallocations.

Table 1: The Distribution of Firms over the Years

Year	Number of firms	Years in the panel	Number of firms
1992	4978	11	1376
1993	5585	10	734
1994	6023	9	743
1995	6282	8	802
1996	6693	7	852
1997	7377	6	1104
1998	8079	5	1381
1999	8568	4	1556
2000	9823	3	2386
2001	9587	2	3230
2002	6817	1	5290
Total number of firm-years	79812	Total number of firms	19454

Table 2: Descriptive Statistics

Variable	Mean	SD	Minimum	Maximum
Revenue	269.953	3492.614	0.001	346231.6
Value Added	75.438	1077.727	-7603.024	104302.8
Labor	77.165	325.598	5	22851
Capital	95.623	1838.607	.00026	230390.4
Materials	194.514	2518.666	.0006	245744
Δ Import penetration ratio	0.014	0.043	-0.165	0.306

Note: the variables are expressed in constant 1992 million forints, labor represents the number of employees at a firm, and import penetration ratio is defined as imports over output less net exports

Table 3: Aggregate Productivity Growth

Year	Productivity Dynamics
1992	0
1993	0.043
1994	0.170
1995	0.294
1996	0.345
1997	0.509
1998	0.544
1999	0.633
2000	0.630
2001	0.847
2002	1.080
Yearly Average	7.70%

Note: For aggregation industry output shares were used. Productivity growth is expressed compared to the base year 1992, which take the value 0.

Table 4: Aggregate Productivity Growth Decompositions

Method	Average yearly productivity growth	Within firm	Between firms	Covariance term	Entry	Exit	Reallocation
BHC[1]	7.70	1.48	6.91		-0.75	-0.06	6.22
FHK[2]	7.70	1.48	-5.88	12.79	-0.75	-0.06	6.22

[1] BHC stands for the Baily et al. (1992) method

[2] FHK stands for the Foster et al. (2001) method

Note: Numbers should be interpreted as percentage points. For aggregation, industry output shares were used. Reallocation is defined as the sum between plants' productivity growth and net entry

Table 5: The Olley-Pakes Decomposition

Year	Average productivity	Covariance term
1992	0.357	0.643
1993	0.329	0.671
1994	0.315	0.685
1995	0.290	0.710
1996	0.294	0.706
1997	0.293	0.727
1998	0.265	0.735
1999	0.277	0.723
2000	0.273	0.727
2001	0.263	0.737
2002	0.282	0.718
Yearly Average	0.292	0.707

Note: For aggregation, industry output shares were used

Table 6: The Effect of Import Competition on Productivity

Dependent variables Specification	Productivity growth (1)	Within firms (2)	Between firms (3)	Entry (4)	Exit[1] (5)	Reallocation R (6)
ΔImportPR	1.623^{***}	-0.281	2.121^{***}	-0.263^{**}	-0.332^{*}	2.115^{***}
	(0.697)	(0.559)	(0.336)	(0.117)	(0.174)	(0.375)
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	220	220	220	220	220	220

[1] Exit here refers to only those plants that according to our coding truly exit.
Note: all variables are expressed relative to the initial industry productivity. In parentheses standard errors are specified.
***, **, and * indicate significance levels at 1%, 5% and 10%

Table 7: The Effect of Import Competition on Productivity - Robustness check

Dependent variables Specification	Productivity growth (1)	Within firms (2)	Between firms (3)	Entry (4)	Exit[1] (5)	Reallocation R (6)
ΔImportPR	1.738^{***}	0.327	1.551^{***}	-0.277^{**}	-0.350^{*}	1.466^{***}
	(0.592)	(0.592)	(0.347)	(0.129)	(0.188)	(0.393)
ΔForeign Share	0.093	0.475^{***}	-0.364^{***}	0.475^{***}	-0.018	-0.373^{***}
	(0.225)	(0.176)	(0.104)	(0.176)	(0.056)	(0.118)
Fixed effects	No	No	No	No	No	No
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	220	220	220	220	220	220

[1] Exit here refers to only those plants that according to the coding system truly exit.
Note: All variables are expressed relative to the initial industry productivity. In parentheses standard errors are specified.
***, **, and * indicate significance levels at 1%, 5% and 10%

Table 8: Import Competition and the Olley-Pakes Reallocation Term

Independent variable	ΔCovariance term Coefficient	Standard errors
ΔImport PR	0.746^{***}	(0.152)
ΔForeign share	0.088^{*}	(0.045)
Fixed effects	No	
Time effects	Yes	
Number of observations	220	

Note: ***,* indicate significance levels at 1% and 10%

Appendix

The Levinsohn - Petrin routine

To estimate the parameters of the production function a two stage procedure is employed, as shown in Petrin, Levinsohn and Poi (2004). Following them, let the production function have the following form:

$$y_t = \beta_l l_t + \phi_t(k_t, m_t) + \xi_t \tag{A1}$$

where y_t now represents value added and

$$\phi_t(k_t, m_t) = \beta_0 + \beta_k k_t + \omega_t(k_t, m_t) \tag{A2}$$

In the first stage, Levinsohn and Petrin (2003) use a third order polynomial approximation of ϕ_t, which is substituted back into (A1) and estimated by a simple OLS. This completes the first stage from where we have an estimate for the coefficient β_l and the function ϕ_t.

In the second stage of this procedure an estimate for the coefficient β_k is provided. First, the estimated value of ϕ_t is computed as

$$\widehat{\phi_t} = \widehat{y_t} - \widehat{\beta_l} l_t$$

For any candidate value β_k^*, one can compute a prediction for ω_t for all periods using

$$\widehat{\omega_t} = \widehat{\phi_t} - \beta_k^* k_t \tag{A3}$$

Using these values, a consistent approximation to $E_t[\omega_t|\omega_{t-1}]$ is given by the predicted values from the regression

$$\widehat{\omega_t} = \gamma_0 + \gamma_1\omega_{t-1} + \gamma_2\omega_{t-1}^2 + \gamma_3\omega_{t-1}^3 + \epsilon_t \tag{A4}$$

Let this predicted value be denoted as $E_t[\omega_t|\widehat{\omega_{t-1}}]$. Thus, the residual becomes

$$\widehat{\eta_t + \xi_t} = y_t - \alpha l_t - \beta_k^* k_t - E_t[\omega_t|\widehat{\omega_{t-1}}] \tag{A5}$$

The estimate for the parameter β_k is defined as the solution to the problem, which can be obtained by using a simple grid search:

$$\min_{\beta_1^*} \sum_t (y_t - \alpha l_t - \beta_1^* k_t - E_t[\omega_t|\widehat{\omega_{t-1}}])^2 \tag{A6}$$

The standard errors for the coefficients of labor l and capital k are obtained from a 50 repetition bootstrap as described in Petrin et al. (2004).

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