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Market Size, Competitiveness and Technological Frontier - the Impact of Trade Integration with the UE on Productivity in Polish Manufacturing Sectors

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Abstract

This paper addresses the relationship between growth of relative productivity in Polish manufacturing sectors and forces stemming from trade integration with the EU. We look at the productivity growth from the perspective of relations between Polish manufacturing sectors and the foreign ones, focusing on partner countries from the enlarged EU. Empirical analysis is based on sector level bilateral data concerning both domestic (Polish) and foreign market characteristics and degree of openness in the period 1995-2006. Main results indicate that, both in the short and long run, growth in domestic openness (independently on the direction of trade flows) exert positive effect on growth of relative productivity in Poland, while the opposite impact is exhibited by foreign openness. In addition, expansion in relative size of Polish sectors versus foreign ones is also among positive determinants of domestic labour productivity growth. The results suggest that domestic openness and market size effects have stimulated movement of Polish sectors towards the technological frontier with respect to the partner countries from the EU.

Key words: labour productivity, trade, integration

JEL classification: F14, F15, F16

1

Introduction

Despite the ongoing development process, Poland still lags behind more advanced EU countries in terms of productivity. According to the recent data (Eurostat, 2010) in 2008 average labour productivity per hour worked (in PPS) relative to EU15 countries in Poland was below half (precisely 44.3 percent) of EU15 average. However, in the process of integration with European and global markets which took place after the economic transformation at the beginning of the 1990s, Poland has managed to bridge part of the productivity gap: in 1995 Polish indicator of productivity per hour worked was only around one-third of the EU15 average (32.3 percent).

Many different factors have been put forward by the literature as potential determinants of productivity growth. Recent theoretical contributions (such as Aghion et al., 2008) suggest that productivity growth process in globalised, integrated economy stems from a mixture of results linked to: the effects on size of the market, increased competition or catching-up process towards the technological frontier. Moreover, short and long run effects on the performance of firms can be different due to the dynamic effects of international exposure of domestic sectors to major competition (Melitz and Ottaviano, 2008). Consequently, productivity developments in domestic sectors, being part of international trade network, will also depend on trends in foreign ones and the interplay between activities performed 'at home' and in foreign economies cannot be separated any more (Chen et al., 2009).

The case of Poland is particularly interesting as it allows to evaluate the relationship between changes in domestic labour productivity and the process of integration with the foreign markets, mainly due to the integration with the EU. Polish economy went through a rapid process of restructuring in early 1990s and already in mid 1990s free trade agreements with EU15 countries were signed. Broad-based domestic reforms in Poland, of which trade liberalization was a part, combined with increased post-liberalization growth, are seen as 'prototypical success story of reform' (Wacziarg and Welch, 2008).

We evaluate the extent to which growth of value added per hour worked in Polish manufacturing was linked to trade liberalization process and procompetitive effects of trade openness. We focus on bilateral differences in productivity levels as a measure of relative distance from the technological frontier between sectors in Poland and in other countries in the EU. However, main aim of this paper is to go beyond traditional analysis of productivity-growth nexus in transition economies, based on descriptive analysis or standard regressions linking productivity with trade openness measures. Several features distinguish our approach.

First of all, we analyse the case of Polish sectors in a setting which allows us to detect the importance of procompetitive effects of integration on domestic economy, at the same time accounting for analogous changes which take place in partner countries. We argue that given the degree of openness of Polish economy with respect to the EU market (in 2009 79.3% of total Polish exports were directed to the EU countries, while 72% of all Polish imports came from the EU)[1] parallel developments in foreign sectors and their impact on the domestic ones cannot be ignored. Consequently, main contribution of the paper is the fact of assessing the importance of integration forces on labour productivity

[1] Statistics refer to EU27 as partner. Data come from the Eurostat.

in Polish manufacturing sectors through the examination of bilateral data, and thus taking into account developments in domestic and foreign sectors at once. We consider relative productivity differences, changes in size and degree of openness characterising 12 manufacturing sectors in Poland *vis-à-vis* the same sectors in each of the EU25 partner countries.[2] Importantly, as partners we consider both 'old' and 'new' member states.

Secondly, we contribute by providing as broad view on the analysed subject as possible. Even though trade remains in the centre of our analysis, we assess not only the impact of trade openness on sector level productivity, but also the influence of enhanced competition from abroad, scale effects, technology transfer and investment flows. As far as trade forces are considered, we distinguish between heterogeneous productivity effects of its various aspects (exports and imports, separately) that take place 'at home' and in partner countries. Furthermore, given increasing importance of trade in intermediate goods, we assess independently the importance of international outsourcing (offshoring) and FDI practices on productivity growth process. Finally, adopted empirical model permits us to distinguish between short run and long run effects of integration on productivity growth in Polish manufacturing.

Merging sector level statistics on all of the aforementioned features from several sources, we base our analysis on a panel dataset composed of 12 manufacturing sectors within the years 1995-2006. Consequently, we are able to analyze the period of rapid integration of the Polish market with the European (and global) economy, since the Europe Agreements till the years following the accession of Poland to the EU.

The rest of the paper is structured as follows: in Section 2 we present the review of related literature, focusing on existing empirical evidence on the impact of trade integration on labour productivity, and theoretical basis for our analysis. In Section 3 our empirical setting is explained along with detailed description of the data used in the study. Next, in Section 4, we present the results of the estimated model. Finally, Section 5 concludes.

Main findings emerging from the analysis are the following: indeed trade openness results to play a role in stimulating productivity growth in Polish manufacturing sectors. However, the perspective of looking at openness (domestic/foreign) is important: we find that the increase in domestic degree of import absorption exerts positive impact on growth of value added per hour worked (both in the short run and in the long run). However, a rise in foreign import openness (considering parallel sectors in the partner country) has the opposite effect on domestic productivity. Similar results appear for trade openness analysed from the point of view of exports. Hence, rise in *relative* degree of Polish manufacturing sectors' openness (domestic *vis-à-vis* foreign) is important for stimulating productivity growth. In addition, we find a robust evidence of positive relationship between labour productivity growth in Polish manufacturing and the relative expansion of the domestic sector, versus the foreign one. The role played by outsourcing is more ambiguous, while inward FDI directed to Poland can be associated with higher domestic productivity growth (the contrary is true for outward FDI).

[2] It was not possible to include Bulgaria and Romania into our analysis due to problems with data availability for these countries.

2

Literature review and theoretical background

2.1 Related empirical literature

When analysing the relationship between productivity and trade flows, we should distinguish between import and export flows that can have different effects on the host economy. Due to our focus on single sectors and adopted disaggregated setting, we leave aside major part of the early studies that analysed trade-productivity nexus from the perspective of countries and were based on traditional (Ricardo, H-O) perspective. Looking from the point of view of firm level analysis which focuses on exporters, their higher productivity can show up through different channels: a) 'self-selection': exporters already had higher productivity before they entered foreign markets and, consequently, their higher post-entry productivity is observed and often misled with the casual effect between exporting activity and productivity (Wagner, 2007; Harris and Li, 2008); b) 'learning-by-exporting': exporters' performance is improved over time through the learning process (Girma, Greenaway and Kneller; 2004, Blalock and Gertler, 2004); (c) intra-industry (i.e. inter-firm) reallocation towards exporting firms takes place (Bernard and Jensen, 2004); d) the shutdown of lower productivity firms.

Empirical literature considering an impact of exporters on productivity growth (or vice versa) is growing fast but the results are not unambiguous. In a recent survey of the literature Wagner (2007), shows through the meta analysis of 54 firm level microstudies that exporting firms are usually more productive than non-exporting, and that more productive firms self-select into the foreign markets, but exporting activity *per se* does not necessarily improve productivity. Interestingly, in a similar meta analysis based on 30 firm level studies, Martins and Yang (2009) conclude that the impact of exporting on productivity is higher for developing than developed economies. The causal relationship between exporting and firm's productivity through 'learning by exporting' was confirmed by (among others) Girma, Greenaway and Kneller, (2004), Blalock and Gertler (2004) and Baldwin and Gu (2004).

Some other papers fund that exporters were already more productive before entering foreign markets (Alvarez and López, 2004; Wagner, 2002) or fund no difference in characteristics between exporting and non-exporting firms (Greenaway, Gullstrand and Kneller, 2005). Herzer (2010a) further challenges the conventional view on the export-productivity nexus and in the study based on a sample of 45 developing countries indicates that exports have a positive short-run effect but negative long-run effect on productivity.

From the perspective of the whole industry, it is important that exporters may increase the productivity of firms in the same industry, even of those that do not export (through horizontal spillovers). They can also affect productivity of their suppliers (backward spillovers) and buyers (forward export spillovers), providing them with improved (cheaper) intermediate inputs (Alvarez and López, 2008).

Similar to the case of exporters, the impact of importers on productivity can be twofold: from importers to rising productivity but also the other way round - self selection of importers can result in causality running from productivity to importers. Looking from the perspective of a single company, importing firm can take advantage of cheaper or higher quality inputs and, hence, lower costs of production and extract technology embodied

in imported intermediated goods. Among others: Andersson, Lööf and Johansson, (2008); Castellani, Serti and Tomasi, (2010) argue that there are strong arguments in favour of a causal effect of imports on productivity. However, Djankov and Murrell, (2002) in their meta analysis of an impact of import penetration on growth, find the positive effect of openness only for Eastern Europe while in case of CIS the opposite tendency prevails. Sato and Fukushige (2007), analysing North Korean economy in the period 1964-2004, showed that during the first half of the analysed period import-led growth effect was observed, while during a second half of the period economic growth was stimulating imports.

Due to increase outsourcing practises (see Martin, 2006 on the international division of labour in Europe) also the specific link between trade in intermediate goods and productivity has been analysed (even though the main strand of literature focuses on the implications of offshoring for domestic labour markets - among others: Feenstra and Hanson, 1999; Hijzen, Görg and Hine, 2005). Theoretically, one should expect positive effects of productivity as a result of outsourcing due to: increased specialization, better reallocation of resources and the possibility to purchase higher-quality and/or cheaper intermediates abroad, reorganizing domestic production to focus on the most efficient stages of the value chain. However, taking into account sector level data and different categories of labour force, Egger and Egger (2006) concluded that as a result of outsourcing practices (materials) in the EU labour productivity of low skilled workers rises only in the long run, but tends to diminish in the short run. Crucial distinction may consider productivity effects of outsourcing of materials and services. Amiti and Wei (2006) confirmed positive relationship between productivity and services outsourcing in the US industries. Görg, Hanley and Strobl, (2008), using plant-level data for Irish manufacturing, found robust evidence for positive effects from outsourcing of services inputs for exporters, both domestic and foreign owned, but no statistically significant evidence of an impact of international outsourcing of services on productivity for firms not operating on the export market. Firm level evidence also confirms self selection mechanisms - more productive firms are more likely to outsource (Tomiura, 2005; Kurz, 2006).

Another strand of the literature on productivity growth in globalized economy concentrates on the impact of FDI. The main theoretical argument is that FDI inflows generate positive spillovers from multinational companies to domestic firms (bringing new knowledge from abroad) through such channels as: the adoption of new methods of production and/or management or human capital transfer (Görg and Greenaway, 2004). FDI inflows create also some additional competition for domestic firms, enhancing their innovation (a similar effect as in case of imports) and exposure to the leading firms. On the other hand, it has also been stated that FDI inflows can be harmful for the indigenous economy because they foster competition with which local firms have no chance to bear, they overuse local resources or cause distortions in the host country's policies so as to benefit the foreign investors (Ram and Honglin Zhang, 2002). As far as Poland is concerned, Kolasa (2008b) focused on Polish corporate sector (firm level data), finding the existence of positive productivity spillovers associated with foreign investment.

The recent literature underlines the important characteristic that host country has to possess in order to take advantage of FDI. Hermes and Lensink (2003), Durham (2004) and Alfaro et al. (2004) point out the importance of financial markets' conditions; Borensztein, De Gregorio and Lee, (1998) find that the effect of inward FDI on growth depends on the level of human capital in the host country; Busse and Groizard (2008) showed that more regulated economies are less able to take advantage of the presence of multinational companies and Balasubramanyam, Salisu and Sapsford, (1996) point at trade openness as the main determinant of pro productive inward FDI.

An impact of outward FDI on productivity has been also analysed. For example, Bitzer and Görg (2009) analysed industry performance of 17 OECD countries over the period 1973 to 2001, founding a positive productivity effects of inward FDI but average negative

influence of outward FDI on TFP (but with a large differences across countries). Outward FDI had the largest negative effect on TFP in South Korea, while the positive effects were found in: France, Japan, Poland, Sweden, the Czech Republic, the UK, and the US. However, Navaretti, Castellani and Disdier, (2010) for the sample of Italian and French firms showed no evidence of a negative effect of outward investments to cheap labour countries, at the same time finding positive effect on output and employment growth in case of Italian firms and positive effect on size of domestic activity in case of French firms. In the recent paper of Herzer (2010b), showing the analysis of 33 developing countries over the period 1980-2005, a long-run relationship between outward FDI and TFP is confirmed, as well a *vice versa* effect.

The empirical literature regarding an impact of different aspects of openness (trade flows and FDI activity) on productivity consists mainly of cross country and firm-level studies. In comparisons to these levels of analysis, studies taking into account the sectoral dimension are less numerous. The recent sector level contributions on trade-productivity nexus consist of: Cameron, Proudman and Redding, (2005); Chen, Imbs and Scott, (2009), Kolasa (2008a) and Bijsterbosch and Kolasa (2010).

Cameron, Proudman and Redding, (2005) confirm the impact of import as a channel of technological transfer for 14 UK manufacturing industries. Chen, Imbs and Scott, (2009) perform the analysis based on a sample of ten manufacture sectors across seven European countries (1989-1999), finding short run evidence that import penetration exerts a positive effect on productivity in domestic sectors, but possible anti-competitive outcomes of openness can emerge in the long run. Kolasa (2008a) focus on 21 manufacturing industries of Polish economy in the period of economic transformation (1994-2002) and did not provide evidence of statistically significant effect of trade (imports) on the host economy. Finally, Bijsterbosch and Kolasa (2010) demonstrate positive impact of FDI inflow on labour productivity growth in nineteen sectors of eight Central and Eastern European EU Member States over the period 1995-2005.

In the resent years, we can observe the growing interest in transition economies and New Member States, due to their integration process creating a natural experiment to test the effects of trade openness on productivity. Results obtained by Çetintaş and Barwik (2009) indicate a causality running from growth to export in a sample of 13 transition economies. Awokuse (2007) investigate the impact of export and import expansion on growth in the Czech Republic, Bulgaria and Poland, finding bidirectional casual relationship between exports and growth for Bulgaria, but only import-led growth was detected in case of the Czech Republic and Poland. The growth-led export effect was confirmed for Romania and Bulgaria during pre-accession period (1991-2001) by Dritsakis (2004). The relationship running from growth to inward FDI was established by Lokar and Bajzikova (2008) in case of Slovakia and Slovenia, although their results indicate positive or negative impact of growth on inward FDI.

The specific case of the link between integration and productivity in Poland was analysed in the aforementioned studies by: Kolasa (2008a and 2008b). To the best of our knowledge there is no published study that takes into account effects of openness on productivity growth in a bilateral setting (Polish versus foreign manufacturing sectors), at the same time allowing for the detection of both short run and long run effects - as in our analysis.

2.2 Adopted theoretical model

Recent contributions suggest that trade can stimulate productivity through a mechanism similar to creative destruction (Aghion and Howitt, 1992). It has been shown that in a globalised economy trade integration operates on productivity through three main

channels: scale effects linked to the increased market size, selection effects of enhanced competition and backwardness effects due to catching up with the technological frontier (Aghion et al., 2008). According to this view in an opening economy trade liberalization enhances product market competition, by allowing foreign producers to compete with the domestic ones, at the same time influencing market size and competitive pressure - as a result domestic productivity should grow. Importantly, in open economy setting domestic and foreign developments matter equally and a broad approach to productivity analysis, not limited to changes taking place 'at home', should be adopted.

Direct theoretical background for our empirical study is based on the model presented in Chen, Imbs and Scott, (2009), and originally derived from the framework presented by Melitz and Ottaviano (2008). The model can be located within the class of recent contributions according to which trade can have positive growth effects on productivity, mainly due to self-selection mechanism and more efficient behaviour of firms exposed to enhanced competition (Melitz 2003, Bernard et al., 2003, 2007a and 2007b, Melitz and Ottaviano, 2008). In particular, Melitz and Ottaviano (2008) model suggests that major openness (import penetration) increases the number of firms and at least in the short run trade should exert positive effects on productivity due to pro-competitive effects, fall in prices and markups. Long-run effects are more ambiguous as firms can adjust and relocate.[3]

Chen, Imbs and Scott (2009) derive a testable version of the aforementioned model of Melitz and Ottaviano (2008), focusing on sector level differences in trade openness in domestic and foreign markets, and resulting effects on: prices, mark-ups and productivity. They present three separate specifications concerning the impact of integration and international competition on these three characteristics of opening sectors, each of which can be estimated independently. We centre our attention on the effects of trade integration on productivity.[4]

What is particularly useful, the derived specification allows us to test short and long run effects of trade openness on productivity, at the same time accounting for heterogeneous effects of domestic (in our case: Polish) and foreign (partner countries from the EU) openness on productivity in Poland. Taking into account bilateral relative differences in productivity (here: value added per hour worked in a manufacturing sector in Poland versus labour productivity in the same sector in each of the partner countries), Chen, Imbs and Scott, (2009) predictions suggest that in the short run a rise in domestic (Polish) openness should boost domestic productivity through a trimming effect on less productive home producers. This effect is conditional upon the size of the market. Foreign degree of openness should exert the opposite effect on domestic productivity in the short run: major foreign exposure to trade fosters competition in the partner country and rises productivity there, thus relative domestic productivity with respect to the foreign one can fall. In the long run, when adjustment mechanisms take place, trade effects on productivity can be more ambiguous. As far as market size is concerned, at least in the short run, rise in domestic size of the sector increases relative domestic productivity, while the opposite effect results from the foreign market size expansion (it rather affects positively foreign productivity levels).

[3] For a full description of the model underlying our empirical analysis we direct the interested reader to the original model in Melitz and Ottaviano (2008).

[4] See Chen, Imbs and Scott, (2009) p. 51-54 for a detailed formal exposure of the model and all the testable specifications.

3

Empirical setting

3.1 Specification of the empirical model

Our empirical setting draws on the theoretical background presented in Section 2.2 and is the slightly modified version of Chen, Imbs and Scott, (2009) model. Our analysis is based on bilateral data concerning manufacturing sectors in Poland (as home country) and statistics referring to sectors in single partner countries from the EU. In order to assess the determinants of growth of relative productivity in Polish manufacturing we adopt the following dynamic econometric specification:

$$\Delta ln(rel\_prod)_{PL,\,p,i,t} = \beta_0 + \beta_1 \Delta ln(rel\_prod)_{PL,\,p,i,t-1} + \beta_2 \Delta ln(size)_{PL,i,t} + \beta_3 \Delta ln(size)_{p,i,t} + \beta_4 \Delta ln(trade)_{PL,i,t} + \beta_5 \Delta ln\,(trade)_{p,i,t} + \beta_6 \Delta ln\,(FDI)_{PL,i,t} + d_t + d_{i,p} + \varepsilon_{PL,\,p,i,t} \qquad (1)$$

where *PL* signifies Poland, *p* denotes foreign partner country, *i* refers to sector and *t* to time period, *d* signifies dummy variable and ε is the error term; *rel_prod* denotes relative labour productivity, *size* – sector dimension, *trade* is the degree of trade openness measured as trade absorption (see below), and FDI denotes foreign direct investment. This is the short run specification with first differences (Δ) capturing short run effects.

Dependant variable is the growth of relative productivity (log difference):

$\Delta ln(rel\_prod)_{PL,\,p,i,t}$ where labour productivity (real value added *VA* per hours worked *H*[5]) in every Polish sector and time period is measured with respect to the productivity in the same sector and time period in the partner country: $(rel\_prod)_{PL,\,p,i,t} = \frac{(VA/H)_{PL,i,t}}{(VA/H)_{p,i,t}}$. In order to account for convergence type mechanism, as first explanatory variable we consider past trends in productivity, $\Delta ln(rel\_prod)_{PL,\,p,i,t-1}$, expecting the coefficient associated with this variable to be negative. Note that we consider relative productivity (in Poland with respect to the same sector in partner country), thus its growth also captures changes in sector specific bilateral differences in relative technology.

Next, we control for the growth in size of the sector in Poland ($\Delta ln(size)_{PL,i,t}$) and analogical growth of the sector size in the partner country ($\Delta ln(size)_{p,i,t}$). Size is measured in terms of real value added (1995, PPS). In line with the theoretical background, we expect that productivity growth is higher in major domestic economy (thus coefficient associated with size of Polish manufacturing sectors should be >0) due to positive scale effects, while size of foreign markets exhibits the negative effect on domestic (Polish) productivity.

The impact of trade forces on productivity developments is addressed in several ways. First, we check the importance of growth of domestic openness, $\Delta ln(trade)_{PL,i,t}$, measured as trade absorption (as in Chen, Imbs and Scott, 2009): ratio of imports relative to the sum of imports and sectoral gross output net of exports. We expect major openness of the domestic sector to be pro-competitive thus β_4 should be positive. Consequently, we also add analogous variable describing trade openness of a partner country, $\Delta ln(trade)_{p,i,t}$. Here, in line with the theory, foreign openness is expected to have the opposite effect on domestic productivity than the domestic one.

[5] We have used the information on hours worked by persons engaged.

Alternatively to the measure of trade absorption based on imports, we consider the ratio of exports relative to the sectoral output. Import and export openness indicators are included as separate variables in distinct specifications due to possible collinearity problems. We consider trade (export and import flows) of each of the countries with the whole world.

Furthermore, due to increasing role of international outsourcing practises in which Poland is involved, we verify the importance of trade in intermediate goods on productivity growth. In order to do so, we substitute all goods trade openness indicators in eq.1 with those referring only to intermediate goods (so instead of *trade* we consider *interm_trade*). We adopt the measure of intermediate goods imports absorption growth: $\Delta ln(interm\_trade)_{PL,i,t}$, obtained as the ratio of intermediate goods imports in each sector relative to the sum of intermediate goods imports and sectoral gross output net of intermediate goods exports in this sector. Classification of intermediate goods comes from Molnar, Pain and Taglioni (2007). Similarly, we take into account growth of intermediate goods imports' absorption in the partner country: $\Delta ln(interm\_trade)_{p,i,t}$. In case of domestic outsourcing as an alternative we also employ more straightforward index calculated as the ratio of imports of intermediate goods to the use of all intermediate goods in a sector ($OutsIndex)_{PL,i,t}$.[6] Theory suggests that outsourcing practises should boost domestic productivity, thus coefficients associated with these variables are expected to be positive. Finally, we incorporate a sector specific measure of FDI (inward and outward stock, alternatively) concerning Polish manufacturing sectors: $\Delta ln(FDI)_{p,i,t}$ (we do not possess analogous information for all the foreign sectors).

In addition to the model described above, we consider the extended specification which takes into account both short run and long run effects on productivity growth (as in the empirical model derived in Chen, Imbs and Scott, 2009, p. 54):

$$\begin{aligned}\Delta ln(rel\_prod)_{PL,\,p,i,t} &= \beta_0 + \beta_1 \Delta ln(size)_{PL,i,t} + \beta_2 \Delta ln(size)_{p,i,t} + \beta_3 \Delta ln(trade)_{PL,i,t} + \\ &+ \beta_4 \Delta ln(trade)_{p,i,t} + \beta_5 \Delta ln\,(FDI)_{PL,i,t} \\ &+ \lambda \left[\begin{array}{l} ln(rel\_prod)_{PL,\,p,i,t-1} + \delta_0 + \delta_1 ln(size)_{PL,i,t-1} + \delta_2 ln(size)_{p,i,t-1} + \\ + \delta_3 ln(trade)_{PL,i,t-1} + \delta_4 ln(trade)_{p,i,t-1} + \delta_5 ln(FDI)_{PL,i,t-1} \end{array} \right] + d_t + d_{ip} + \varepsilon_{PL,p,i,t} \qquad (2)\end{aligned}$$

First differences (Δ) capture short run effects while the whole term in quadratic brackets (error correction) reflects long run effects.[7] All other changes in the specification (such as the substitution of trade openness measures with those referring to intermediate goods exchange only) is done as in case of eq. 1.

Due to the dynamic specification and possible endogeneity problems the models are estimated using two-step system GMM estimator (Arellano and Bover, 1995; Roodman, 2009), suitable for cases of large n and small t. All the endogenous variables are instrumented by their own lags. In order to control for business cycle effects and sector specificities, full sets of time and sector-partner dummies (d_t and d_{ip}, respectively) are included.

[6] Unfortunately such a measure cannot be counted for partner countries because we do not dispose of the sector level information on the use of all intermediate goods in partner countries (such statistics come from OECD STAN database which includes only selected EU countries).

[7] Equation (2) can be referred to a single-equation error correction model:
$\Delta Y_t = a_0 - a_1 (Y_{t-1} - b_1 X_{t-1}) + b_0 \Delta X_t + \varepsilon_t$ where the current changes in dependent variable (ΔY_t) are determined by current changes in independent variable (ΔX_t) and the extent to which these two time series X and Y were outside the equilibrium in the previous time ($Y_{t-1} - b_t X_{t-1}$). The short term effect of X on Y is measured by the parameter in front of the first difference of X: (b_0). The long term effect of X on Y (sometimes called long run multiplier) equals (b_1). The parameter (a_1) specifies the speed of adjustment at which the deviations from the equilibrium are corrected. After simple transformations we can arrive to the modified version of the model shown in eq. 2.

3.2 Description of the data used in the study

The aim is to construct a disaggregated level database combining trade and industrial observations on Polish manufacturing sectors and analogous disaggregated data for Poland's partner countries from the EU (thus the final dataset has four dimensions: reporter – Poland, partner, sector and year).

Main source of sector level labour statistics is EUKLEMS database (for a thorough description see O'Mahony and Timmer, 2009). We have combined the data from two revisions (2008 and 2009)[8], using the latest one as a base. The EUKLEMS database has a great advantage of providing comparable (across countries and time periods) data concerning output, value added, hours worked, employment and other statistics for almost all EU member countries disaggregated into industries according to NACE division.

In case of selected countries (non euro zone members) gross output (GO) and value added (VA), originally given by EUKLEMS in national currencies, were reported into euro using current exchange rates from Eurostat. Then, all the series concerning output and value added were reported into real terms (1995=100), using industry and country specific price indices (separate for GO and VA) from EUKLEMS and expressed in PPS terms (using PPS indices from the Eurostat for the base year).

Labour productivity is expressed in constant terms (1995=100) and is measured as: real value added per hour worked in PPS (using PPS indices for the base year). We have used alternatively information on hours worked by persons engaged and by employees, thus in the end our productivity data consists of two alternative variables: real value added per hour worked by persons engaged (PPS, 1995) and real value added per hour worked by employees (PPS, 1995). We use the first one in the basic specification, while the second measure is employed to perform one of the robustness checks.

We merge the industrial statistics described above with trade data coming from UNComtrade (obtained through WITS[9]). The software permits the extraction of export and import data in alternative disaggregation schemes. Making use of 'NACE 4 Ms Woertz' division, we can match trade statistics with productivity and output measures based on EUKLEMS at the level of single manufacturing activities. Correspondence table between labour and trade sectors is presented in Table A2 in the Appendix. Trade statistics were originally reported in current US$ thus in order to be able to calculate trade openness measures we used annual exchange rates euro-US$ from IMF. With these combined labour and trade data we are able to calculate several indicators of trade openness, taking into account: the typology of flow (imports versus exports) and type of goods traded (all goods versus intermediate goods only). In particular, the matching between data on trade in intermediate goods and labour statistics proved to be important, because enabled us to obtain sector level outsourcing proxy.[10] Firstly, on a basis of 5-digit trade statistics (SITC rev.3) from UNComtrade, we individuated goods that are classified as intermediates being subject to outsourcing practices (according to the list of goods in Molnar, Pain and Taglioni, 2007 p. 69-70). Next, for each year we summed values of trade in such goods (imports and exports separately) within each Polish manufacturing sector taken into account by our study. In the first instance we use the data on intermediate goods trade with the whole year, then limiting as flows to those coming from/sent to EU25, EU15, NMS10. Finally, we merge flows of intermediates with output and value added data in a given sector. We repeat the whole

[8] Release November 2009 is an update of the earlier releases of EU KLEMS (March 2007, March 2008) and contains time series from 1970 (mainly for EU15 countries) or 1995 (NMS) up to 2007 (or 2006). However, some of the statistics are only available in revisions prior to 2009. Detailed information on sources and methods can be found at: www.euklems.net.

[9] World Integrated Trade Solutions (www.wits.worldbank.org/witsweb).

[10] Alternatively, input-output tables could be used to construct more direct outsourcing proxies. However, in case of Poland they are available only for selected years (for example waves 2000 or 2005) and, moreover, it would be impossible to have analogous indicators for all the partner countries in our sample.

procedure for every partner country in order to have intermediate goods trade absorption ratios not only for Poland, but also for every partner country. Alternatively, in case of Poland we employ the ratio of intermediate goods imports to the total use of intermediate inputs in a given sector (the latter statistic comes from OECD STAN database).

Finally, we use FDI statistics (with Poland as reporting country) from the WIIW Database on Foreign Direct Investment in Central, East and Southeast Europe, containing information of flows and stock (inward and outward) by sector or by type of the FDI (for details see Hunya, 2010). Following Bitzer and Görg (2009), to capture the effects of FDI especially in the long-run, we express FDI in stocks rather than FDI flows. We distinguish between FDI inward stock and FDI outward stock that, analogously to the import and export flows can influence domestic productivity differently.

In the end, our panel database consists of combined data for Polish and its partner countries' 12 manufacturing sectors[11] within the years 1995-2006. List of our sectors is presented in Table A1 in the Appendix. List of countries is included in Table A3 in the Appendix.

3.3 Empirical evidence on productivity in Polish manufacturing

In Table 1 we present average levels of labour productivity in Polish manufacturing sectors, expressed in real PPS terms (with 1995 as a base year) as an index with respect to typical level of productivity in EU15 countries.

Table 1. Productivity levels in Polish manufacturing sectors in 1995 and 2006

	Real VA/hours worked* (PPS, EU15=100)		Real GO/hours worked* (PPS, EU15=10)	
Sector	1995	2006	1995	2006
Food, beverages and tobacco	36	88	38	72
Textiles, leather and footwear	31	42	26	41
Wood and products of wood and cork	43	74	46	70
Pulp, paper, printing and publishing	56	58	54	76
Chemicals and chemical products	33	52	38	67
Rubber and plastics products	49	88	51	112
Other non-metallic mineral products	33	200**	37	95
Basic metals and fabricated metal products	43	93	48	93
Machinery, n.e.c.	34	93	33	81
Electrical and optical equipment	36	44	35	60
Transport equipment	31	70	31	82
Manufacturing n.e.c; recycling	45	71	49	74
*Total manufacturing****	*39*	*81*	*40*	*77*
Total economy	*39*	*53*	*42*	*60*

Note: all series deflated using sector specific value added and gross output (respectively) price indices *persons engaged; **big value due to considerable change in value added price index in this sector after the year 2000; ***excluding coal, fuel and refined petroleum sector.

Source: own elaboration based on EUKLEMS data

[11] 10 sectors if FDI variables are included. We have excluded sector concerning coal, petroleum etc. as a very specific activity with characteristics of a strong outlier.

Levels of labour productivity in Poland in 1995 were much lower than EU15 standards. Taking into account the data for total economy (last row in Table 1), the indicator of productivity in Poland was only around 39% of EU15 average in terms of VA per hours worked and 42% in terms of gross output per hours worked (all values take into account differences in the purchasing power between Poland and EU countries). However, comparing these values to those in 2006, the process of productivity catching up is clearly visible. Moreover, growth of relative labour productivity with respect to more advanced EU countries was quicker in manufacturing than in the whole Polish economy treated as an aggregate. In 2006 productivity per hour worked in Polish manufacturing was already equal to approximately 80% of EU15 average. There are also big differences across manufacturing sectors, both when we look at levels and changes in productivity. Hence, we confirm that it is important to account for this cross-sectoral heterogeneity in the empirical analysis on the determinants of labour productivity growth.

4

Results of the empirical model estimation

The first step in the econometric analysis is to check for stationarity in the data. Table A4 in the Appendix presents the results of Im-Pesaran-Shin (2003) panel unit root test, with the null hypothesis that all panels have a unit root and the alternative one saying that the fraction of panels that are stationary is nonzero. Given the limited time dimension of our panel, the procedure allowing for individual unit root process is highly desirable. The first column of Table A4 present the test for variables in levels: the null hypotheses state that the logs of our variables contain a unit root. In almost all cases they are accepted, since the p-values are greater than 0.05. In the next column, there are shown the results of the test which refer to the null hypotheses, stating that the first differences of the variables contain unit roots. All null hypotheses for the first differences are rejected. The results of IPS tests indicate that all analysed variables are I(1), thus give us the reason to suspect cointegration. In such case, an error correction model should be applied.

In the subsequent tables we show estimation results based on theoretical background and assessing separately the impact of import openness and export openness on productivity growth in Polish manufacturing sectors. We present separately the results based on specifications concerning only short run[12] (as in eq. 1) or both short run and long run effects (as in eq. 2). AR and Hansen tests perform well in vast majority of cases, thus we conclude that the adopted specification is adequate.

4.1 Productivity growth versus import openness

In Table 2 we present our results on the effect of import openness on relative productivity in the short run. As expected, in all of the specifications coefficients associated with past trends in productivity growth result to be negative and statistically significant. The size effect also appears to be as predicted: the rise in the size of a given domestic sector tends to be linked to the rise in domestic relative productivity; the contrary is true in case of sector's size in partner country. The p-values of the tests of size coefficients' equality allow us to reject the hypothesis that the coefficients on domestic and foreign size are equal.

Key results concern the relationship between trade openness measures (here: import absorption of sectors) and sector level productivity growth. In line with the predictions of the theoretical model, Polish domestic import openness ($\Delta ln(trade)_{PL,i,t}$ where $trade=import$) increases productivity at home while partner's import openness has the opposite effect. These conclusions hold if the openness is measured by a relative term (without distinguishing between domestic and foreign openness separately): $\Delta ln(rel\_trade)_{PL,p,i,t}$. The higher the growth of domestic import absorption with respect to the foreign one, the higher the rise in domestic productivity. Hence we can conclude that domestic import openness exerts positive impact on productivity growth in the short run, rise in the openness of partner countries diminishes it. We also report the p-values of the tests of trade coefficients' equality (we can reject the hypothesis that the coefficients on domestic and foreign openness are equal).

[12] Under non-stationarity, the estimations carried on first differences are consistent but not efficient.

Table 2. Productivity versus import penetration (trade=import) and inward FDI, short run effects

dependent variable: growth of relative labour productivity: $\Delta ln(rel\_prod)_{PL,p,i,t}$,
where *PL*- Poland, *p*- partner, *i*- sector, *t*- time

	(1)	(2)	(3)	(4)
$\Delta ln(rel\_prod)_{PL,p,i,t-1}$	-0.036***	-0.038***	-0.035***	-0.081***
	[0.002]	[0.001]	[0.001]	[0.004]
$\Delta ln(size)_{PL,i,t}$	0.997***	0.996***	0.996***	0.886***
	[0.002]	[0.002]	[0.002]	[0.006]
$\Delta ln(size)_{p,i,t}$	-0.805***	-0.797***	-0.807***	-0.739***
	[0.003]	[0.003]	[0.003]	[0.007]
$\Delta ln(trade)_{PL,i,t}$	0.180***	0.185***	0.176***	0.208***
	[0.003]	[0.002]	[0.003]	[0.006]
$\Delta ln(trade)_{p,i,t}$	-0.012***	-0.009***	-0.011***	-0.034***
	[0.001]	[0.001]	[0.000]	[0.002]
$\Delta ln(interm\_trade)_{PL,i,t}$		-0.005**		
		[0.002]		
$\Delta ln(interm\_trade)_{p,i,t}$		-0.003*		
		[0.002]		
$\Delta ln\ (OutsIndex)_{PL,i,t}$			-0.001	
			[0.002]	
$\Delta ln(FDI\_in)_{PL,i,t}$				-0.002
				[0.002]
AR(1)	0.00	0.00	0.00	0.00
AR(2)	0.163	0.174	0.163	0.03
Hansen test	0.08	0.876	0.149	0.049
N	2754	2746	2754	2065
$\Delta ln(size)_{PL,i,t} = (-1)\ \Delta ln(size)_{p,i,t}$	0.00	0.00	0.00	0.00
$\Delta ln(trade)_{PL,i,t} = (-1)\ \Delta ln(trade)_{p,i,t}$	0.00	0.00	0.00	0.00

Notes: all computations made using XTABOND2 for StataSE 11. Partner's country/sector fixed effects and time effects included in all regressions. All explanatory variables treated as endogenous and instrumented by their own lags. Standard errors in parenthesis. Statistically significant at ***1, **5, *10 percent level. Results are reported for two-step system GMM estimator. The figures reported for Hansen test and Arellano-Bond test are the p-values. The last two rows of the table report the p-values of the tests of coefficients' equality (we can reject the hypothesis that the coefficients on domestic and foreign size are equal, and the hypothesis that the coefficients on domestic and foreign openness are equal).

Source: own elaboration

Results reported in Column 2 and 3 take also into account other form of imports - import of intermediate goods. Contrary to what the positive theory of outsourcing would suggest, it turns out that in case of Polish manufacturing, at least in the short run, major openness of intermediate goods imports is associated negatively with domestic productivity growth. The same effect is true in case of intermediate goods trade of partner countries. In Column (3) we employ our alternative index of domestic outsourcing: import of intermediate goods in relation to the intermediate inputs, but the coefficient is not statistically significant. Hence, short run evidence concerning outsourcing is not conclusive.

Finally, we consider the importance of growth in inward FDI stock – here it does not result to be among statistically significant determinants of productivity growth in Polish manufacturing sectors in the short run (Column 4) - drop in the number of observations is due to restricted sector level FDI data availability.

In Table 3 we present results referring to import activity (and inward FDI) and taking into account also controls in the form of long run effects. Comparing these results with the previous ones, taking into account only short run trends, in first instance we can notice that in general, as before, domestic size exerts positive effect of productivity and partners' size – negative effect. Similarly, growth in relative domestic import penetration with respect to the foreign one is positively associated with productivity growth at home. So, pro-competitive effects of relative home openness and relative home size are confirmed. As far as domestic outsourcing activity in this specification is concerned, in the extended equation it generally results to be significant and positive (Columns 2 and 3). Finally, if we account for long run FDI effects (not statistically significant), there only appears to be a positive effect of FDI inward stock growth on productivity growth in the short period.

Table 3. Productivity versus import penetration (trade=import) and inward FDI, long run effects

dependent variable: growth of relative labour productivity: $\Delta ln(rel\_prod)_{PL,p,i,t}$,
where *PL*- Poland, *p*- partner, *i*- sector, *t*- time

	(1)	(2)	(3)	(4)
$ln(rel\_prod)_{PL,p,i,t-1}$	-0.044***	-0.049***	-0.046***	-0.047***
	[0.001]	[0.001]	[0.001]	[0.002]
$\Delta ln(size)_{PL,i,t}$	1.000***	1.002***	1.004***	0.895***
	[0.001]	[0.002]	[0.001]	[0.003]
$ln(size)_{PL,i,t-1}$	0.038***	0.047***	0.042***	0.028***
	[0.001]	[0.001]	[0.001]	[0.002]
$\Delta ln(size)_{p,i,t}$	-0.709***	-0.735***	-0.721***	-0.651***
	[0.004]	[0.003]	[0.004]	[0.005]
$ln(size)_{p,i,t-1}$	-0.013***	-0.014***	-0.014***	-0.012***
	[0.000]	[0.000]	[0.000]	[0.001]
$\Delta ln(trade)_{PL,i,t}$	0.172***	0.155***	0.161***	0.211***
	[0.002]	[0.002]	[0.002]	[0.003]
$ln(trade)_{PL,i,t-1}$	0.018***	0.006***	0.007***	0.025***
	[0.001]	[0.001]	[0.001]	[0.002]
$\Delta ln(trade)_{p,i,t}$	-0.030***	-0.019***	-0.026***	-0.049***
	[0.001]	[0.001]	[0.001]	[0.002]
$ln(trade)_{p,i,t-1}$	-0.021***	-0.017***	-0.017***	-0.034***
	[0.001]	[0.001]	[0.001]	[0.002]
$\Delta ln(interm\_trade)_{PL,i,t}$		0.034***		
		[0.002]		
$ln(interm\_trade)_{PL,i,t-1}$		0.004***		
		[0.001]		
$\Delta ln(interm\_trade)_{p,i,t}$		-0.002		
		[0.002]		
$ln(interm\_trade)_{p,i,t-1}$		0.003***		
		[0.001]		
$\Delta ln\ (OutsIndex)_{PL,i,t}$			0.020***	
			[0.002]	

Table 3. Cont.

	(1)	(2)	(3)	(4)
$ln\ (OutsIndex)_{PL,i,t-1}$			0.006*** [0.000]	
$\Delta ln(FDI\_in)_{PL,i,t}$				0.006*** [0.002]
$ln(FDI\_in)_{PL,i,t-1}$				-0.001 [0.001]
AR(1)	0.000	0.000	0.000	0.00
AR(2)	0.554	0.429	0.478	0.235
Hansen test	0.451	0.99	0.612	0.99
N	3030	3021	3030	2065

Notes: all computations made using XTABOND2 for StataSE 11. Partner's country/sector fixed effects and time effects included in all regressions. All explanatory variables treated as endogenous and instrumented by their own lags. Standard errors in parentheses. Statistically significant at ***1, **5, *10 percent level. Results are reported for two-step system GMM estimator. The figures reported for Hansen test and Arellano-Bond test are the p-values.

Source: own elaboration

4.2 Productivity growth versus export openness

As an alternative to the model taking into account import openness, we present analogous results obtained with the use of: export penetration as a measure of openness and outward FDI instead of inward FDI. In Table 4 only short run effect is encompassed, while in Table 5 we show the results correcting also for the long-run effect.

Apart from few exceptions, the results reported in Table 4 and Table 5 are very similar to those obtained with imports. Impact of past trends in productivity on its growth is negative as before. Moreover, positive effect of domestic size (and negative effect of foreign size) on relative productivity growth in Polish sectors is also confirmed.

Turning to crucial openness indicators, domestic export openness is related to higher labour productivity growth, thus apart from import-led growth found previously we can also confirm the hypothesis of export-led productivity growth. Rise in partners' export openness has the opposite effect on Polish productivity. Therefore, as found in case of imports, relative degree of sectoral openness is important from the point of view of labour productivity developments at home.

Table 4. Productivity versus export penetration (trade=export) and outward FDI, short run effects

dependent variable: growth of relative labour productivity: $\Delta ln(rel\_prod)_{PL,p,i,t}$,
where *PL*- Poland, *p*- partner, *i*- sector, *t*- time

	(1)	(2)	(3)
$\Delta ln(rel\_prod)_{PL,p,i,t-1}$	-0.039*** [0.002]	-0.041*** [0.001]	-0.088*** [0.004]
$\Delta ln(size)_{PL,i,t}$	0.983*** [0.002]	0.983*** [0.002]	0.860*** [0.004]
$\Delta ln(size)_{p,i,t}$	-0.796*** [0.004]	-0.786*** [0.002]	-0.758*** [0.006]
$\Delta ln(trade)_{PL,i,t}$	0.093*** [0.002]	0.058*** [0.002]	0.089*** [0.003]

Table 4. Cont.

	(1)	(2)	(3)
$\Delta ln(trade)_{p,i,t}$	-0.055*** [0.001]	-0.051*** [0.001]	-0.047*** [0.002]
$\Delta ln(interm\_trade)_{PL,i,t}$		0.031*** [0.001]	
$\Delta ln(interm\_trade)_{p,i,t}$		0.001*** [0.000]	
$\Delta ln(FDI\_out)_{PL,i,t}$			-0.002*** [0.000]
AR(1)	0.00	0.00	0.00
AR(2)	0.112	0.104	0.056
Hansen test	0.079	0.85	0.099
N	2758	2755	1701
$\Delta ln(size)_{PL,i,t} = (-1)\ \Delta ln(size)_{p,i,t}$	0.00	0.00	0.00
$\Delta ln(trade)_{PL,i,t} = (-1)\ \Delta ln(trade)_{p,i,t}$	0.00	0.00	0.00

Notes: all computations made using XTABOND2 for StataSE 11. Partner's country/sector fixed effects and time effects included in all regressions. All explanatory variables treated as endogenous and instrumented by their own lags. Standard errors in parentheses. Statistically significant at ***1, ** 5, * 10 percent level. Results are reported for two-step system GMM estimator. The figures reported for Hansen test and Arellano-Bond test are the p-values. The last two rows of the table report the p-values of the tests of coefficients' equality (we can reject the hypothesis that the coefficients on domestic and foreign size are equal, and the hypothesis that the coefficients on domestic and foreign openness are equal).

Source: own elaboration

Taking into account intermediate goods export penetration, in the short run (Column 2 of Table 4) we find positive effect of both domestic and partner's trade in such goods on labour productivity growth in Polish sectors. When we take into account also the long-run trends (Column 2 of Table 5), then we can notice that both domestic and foreign effects are positive but since the latter's magnitude is higher, the relationship between domestic productivity growth and relative measure of intermediate goods trade openness (see robustness check section) can be negative. These results are in line with the latest study of Herzer (2010a) who found positive export-led growth effect in the short run and negative in the long run.

Finally, both in the short run and in the long run specification we rather find the negative (or insignificant) effect of outward FDI on domestic productivity growth in Polish manufacturing.

Table 5. Productivity versus export penetration (trade=export) and outward FDI, long run effects

dependent variable: growth of relative labour productivity: $\Delta ln(rel\_prod)_{PL,p,i,t}$,
where PL- Poland, p- partner, i- sector, t- time

	(1)	(2)	(3)
$ln(rel\_prod)_{PL,p,i,t-1}$	-0.048*** [0.001]	-0.061*** [0.001]	-0.039*** [0.001]
$\Delta ln(size)_{PL,i,t}$	0.990*** [0.002]	0.988*** [0.002]	0.883*** [0.002]
$ln(size)_{PL,i,t-1}$	0.038*** [0.001]	0.052*** [0.001]	0.023*** [0.001]

Table 5. Cont

	(1)	(2)	(3)
$\Delta ln(size)_{p,i,t}$	-0.708***	-0.729***	-0.685***
	[0.003]	[0.003]	[0.003]
$ln(size)_{p,i,t-1}$	-0.013***	-0.017***	-0.007***
	[0.000]	[0.000]	[0.001]
$\Delta ln(trade)_{PL,i,t}$	0.079***	0.055***	0.114***
	[0.002]	[0.002]	[0.001]
$ln(trade)_{PL,i,t-1}$	0.013***	0.005***	0.015***
	[0.001]	[0.001]	[0.001]
$\Delta ln(trade)_{p,i,t}$	-0.038***	-0.042***	-0.039***
	[0.001]	[0.001]	[0.002]
$ln(trade)_{p,i,t-1}$	-0.008***	-0.016***	-0.012***
	[0.001]	[0.001]	[0.001]
$\Delta ln(interm\_trade)_{PL,i,t}$		0.050***	
		[0.001]	
$ln(interm\_trade)_{PL,i,t-1}$		0.001**	
		[0.000]	
$\Delta ln(interm\_trade)_{p,i,t}$		0.005***	
		[0.000]	
$ln(interm\_trade)_{p,i,t-1}$		0.008***	
		[0.000]	
$\Delta ln(FDI\_out)_{PL,i,t}$			-0.002***
			[0.000]
$ln(FDI\_out)_{PL,i,t-1}$			-0.002***
			[0.000]
AR(1)	0.000	0.000	0.000
AR(2)	0.417	0.372	0.247
Hansen test	0.445	0.99	0.983
N	3034	3030	1701

Notes: all computations made using XTABOND2 for StataSE 11. Partner's country/sector fixed effects and time effects included in all regressions. All explanatory variables treated as endogenous and instrumented by their own lags. Standard errors in parentheses. Statistically significant at ***1, **5, *10 percent level. Results are reported for two-step system GMM estimator. The figures reported for Hansen test and Arellano-Bond test are the p-values.

Source: own elaboration

4.3 Robustness checks

We have addressed the robustness of our findings in several ways. At first, in alternative specifications instead of considering both domestic and foreign (partner) size, we insert into the empirical model relative measure of size, being the log difference of Polish sector size and partner's sector size (as in Aghion et al. 2008). Similar exercise is repeated for trade penetration measures. The corresponding results, respectively referring to imports and exports, are presented in Table 6. As expected, the coefficients related to these relative measures are positive (Columns 1a and 1b for relative size; Columns 2a and 2b for relative openness; Columns 3a and 3b for relative intermediate goods trade openness) which confirms our main findings on the importance of openness and scale effects at home with respect to developments in partner countries.

In the following step, we augmented the econometric specification by considering additional left hand side variables (capital – Table 7; human capital, R&D, wages – Table 8).

Table 6. Robustness check (I) – relative measures of size and openness

dependent variable: growth of relative labour productivity: $\Delta ln(rel\_prod)_{PL,p,i,t}$,
where *PL*- Poland, *p*- partner, *i*- sector, *t*- time

	Trade =Import			*Trade =Export*		
	(1a)	(2a)	(3a)	(1b)	(2b)	(3b)
$\Delta ln(rel\_prod)_{PL,p,i,t-1}$	-0.042*** [0.002]	-0.041*** [0.002]	-0.038*** [0.001]	-0.048*** [0.002]	-0.041*** [0.002]	-0.040*** [0.001]
$\Delta ln(size)_{PL,i,t}$		0.978*** [0.004]	0.998*** [0.002]		0.979*** [0.004]	0.981*** [0.001]
$\Delta ln(size)_{p,i,t}$		-0.790*** [0.006]	-0.795*** [0.002]		-0.772*** [0.007]	-0.791*** [0.002]
$\Delta ln(trade)_{PL,i,t}$	0.159*** [0.005]		0.181*** [0.002]	0.099*** [0.004]		0.092*** [0.001]
$\Delta ln(trade)_{p,i,t}$	-0.033*** [0.002]		-0.010*** [0.001]	-0.086*** [0.004]		-0.052*** [0.001]
$\Delta ln(rel\_size)_{PL,p,i,t}$	0.952*** [0.003]			0.952*** [0.003]		
$\Delta ln(rel\_trade)_{PL,p,i,t}$		0.073*** [0.003]			0.085*** [0.003]	
$\Delta ln(rel\_interm\_trade)_{PL,p,i,t}$			0.001 [0.001]			0.001*** [0.000]
AR(1)	0.00	0.00	0.00	0.00	0.00	0.00
AR(2)	0.104	0.126	0.162	0.055	0.125	0.113
Hansen test	0.009	0.009	0.77	0.014	0.005	0.751
N	2754	2754	2746	2758	2758	2755

Notes: all computations made using XTABOND2 for StataSE 11. Partner's country/sector fixed effects and time effects included in all regressions. All explanatory variables treated as endogenous and instrumented by their own lags. Standard errors in parenthesis. Statistically significant at ***1, **5, *10 percent level. Results are reported for two-step system GMM estimator. The figures reported for Hansen test and Arellano-Bond test are the p-values.

Source: own elaboration

First of all, we include the growth of capital accumulation per hour worked in Polish sectors.[13] The capital stock was calculated using the perpetual inventory method with the utilisation of gross fixed capital formation and depreciation rate of 6% (see for example Caselli, 2005 for the description of methodology). In line with the predictions, change in capital results to be positively linked to productivity growth, and the other crucial results described above hold.

Next, we consider the degree of domestic competition proxied by price cost margin (*PCM*) and measured as in Aghion et al. (2007) and being the difference between value added (*VA*) and labour compensation (*LAB_COMP*) expressed as a proportion of gross output (*GO*):

[13] We do not dispose of statistics enabling us to count capital in every partner country, thus we are not able to include a measure of *cap_part* into the model.

$$PCM_i = \frac{VA_i - LAB\_COMP_i}{GO_i} \qquad (3)$$

where i refers to sector. We include lagged (PCM) measures concerning both Polish $(PCM)_{PL,i,t-1}$ and partner countries' $(PCM)_{p,i,t-1}$ degree of competition. PCM expresses the Lerner index of pricing power, it is in the range (0,1) – the higher the index, the higher the pricing power and the lower the competitive pressure. Looking at Columns 1a and 1b of Table 8, we can see that major domestic competition stimulates relative labour productivity growth in Polish manufacturing sectors, while rise in competitive pressure abroad enhances productivity growth there and thus exhibits negative effect on Polish relative productivity. Again, results concerning the impact of market size and openness at home and abroad remain stable with respect to the benchmark ones.

Table 7. Robustness check (II) – inclusion of capital into the empirical model

dependent variable: growth of relative labour productivity: $\Delta ln(rel\_prod)_{PL,p,i,t}$,
where PL- Poland, p- partner, i- sector, t- time

	Trade =Import		*Trade =Export*	
	(1a)	(2a)	(1b)	(2b)
$\Delta ln(rel\_prod)_{PL,p,i,,t-1}$	-0.032***	-0.033***	-0.032***	-0.032***
	[0.001]	[0.001]	[0.001]	[0.001]
$\Delta ln(size)_{PL,i,t}$	0.993***	0.991***	0.982***	0.980***
	[0.002]	[0.002]	[0.002]	[0.002]
$\Delta ln(size)_{p,i,t}$	-0.822***	-0.815***	-0.816***	-0.816***
	[0.003]	[0.003]	[0.003]	[0.002]
$\Delta ln(trade)_{PL,i,t}$	0.134***	0.134***	0.040***	0.049***
	[0.003]	[0.002]	[0.002]	[0.001]
$\Delta ln(trade)_{p,i,t}$	-0.009***	-0.005***	-0.055***	-0.044***
	[0.001]	[0.000]	[0.001]	[0.002]
$\Delta ln(interm\_trade)_{PL,i,t}$		0.017***	0.043***	0.043***
		[0.002]	[0.002]	[0.002]
$\Delta ln(interm\_trade)_{p,i,t}$		-0.007***	-0.009***	-0.009***
		[0.001]	[0.002]	[0.002]
$\Delta ln(cap)_{PL,i,t}$	0.175***	0.181***	0.213***	0.214***
	[0.003]	[0.002]	[0.003]	[0.002]
AR(1)	0.00	0.00	0.00	0.00
AR(2)	0.175	0.177	0.132	0.138
Hansen test	0.156	0.914	0.138	0.907
N	2754	2746	2758	2748
$\Delta ln(size)_{PL,I,t} = (-1)\ \Delta ln(size)_{p,i,t}$	0.00	0.00	0.00	0.00
$\Delta ln(trade)_{PL,i,t} = (-1)\ \Delta ln(trade)_{p,i,t}$	0.00	0.00	0.00	0.00

Notes:all computations made using XTABOND2 for StataSE 11. Partner's country/sector fixed effects and time effects included in all regressions. All explanatory variables treated as endogenous and instrumented by their own lags. Standard errors in parenthesis. Statistically significant at ***1, **5, *10 percent level. Results are reported for two-step system GMM estimator. The figures reported for Hansen test and Arellano-Bond test are the p-values. The last two rows of the table report the p-values of the tests of coefficients' equality (we can reject the hypothesis that the coefficients on domestic and foreign size are equal, and the hypothesis that the coefficients on domestic and foreign openness are equal.

Source: own elaboration

Table 8. Robustness check (III) – inclusion of price cost margin, skill intensity (human capital) and R&D measures into the empirical model

dependent variable: growth of relative labour productivity: $\Delta ln(rel\_prod)_{PL,p,i,t}$, where PL- Poland, p- partner, i- sector, t- time

	Trade =Import			*Trade=Export*		
	(1a)	(2a)	(3a)	(1b)	(2b)	(3b)
$\Delta ln(rel\_prod)_{PL,p,i,,t-1}$	-0.032***	0.003*	-0.036***	-0.032***	0.00	-0.039***
	[0.001]	[0.001]	[0.002]	[0.001]	[0.001]	[0.002]
$\Delta ln(size)_{PL,i,t}$	0.901***	0.977***	0.997***	0.876***	0.962***	0.983***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
$\Delta ln(size)_{p,i,t}$	-0.786***	-0.898***	-0.805***	-0.761***	-0.902***	-0.796***
	[0.002]	[0.003]	[0.003]	[0.002]	[0.005]	[0.004]
$\Delta ln(trade)_{PL,i,t}$	0.121***	0.136***	0.180***	0.050***	0.078***	0.093***
	[0.002]	[0.003]	[0.003]	[0.002]	[0.002]	[0.002]
$\Delta ln(trade)_{p,i,t}$	-0.012***	-0.009***	-0.012***	-0.038***	0.005	-0.055***
	[0.001]	[0.001]	[0.001]	[0.002]	[0.004]	[0.001]
$ln(PCM)_{PL,i,t-1}$	-0.025***			-0.030***		
	[0.000]			[0.001]		
$ln(PCM)_{p,i,t-1}$	0.022***			0.021***		
	[0.000]			[0.001]		
$ln\ (LS)_{PL,i,t-1}$		-0.023***			-0.022***	
		[0.001]			[0.001]	
$ln(LS)_{p,i,t-1}$		0.00			0.001	
		[0.000]			[0.001]	
$\Delta ln(RD)_{PL,t}$			0.022***			0.038***
			[0.005]			[0.004]
AR(1)	0.00	0.00	0.00	0.00	0.00	0.00
AR(2)	0.069	0.677	0.163	0.045	0.337	0.112
Hansen test	0.967	0.99	0.08	0.97	0.99	0.079
N	2674	2155	2754	2678	2159	2758
$\Delta ln(size)_{PL,i,t} =$ $(-1)\ \Delta ln(size)_{p,i,t}$	0.00	0.00	0.00	0.00	0.00	0.00
$\Delta ln(trade)_{PL,i,t} =$ $(-1)\ \Delta ln(trade)_{p,i,t}$	0.00	0.00	0.00	0.00	0.00	0.00

Notes: all computations made using XTABOND2 for StataSE 11. Partner's country/sector fixed effects and time effects included in all regressions. All explanatory variables treated as endogenous and instrumented by their own lags. Standard errors in parenthesis. Statistically significant at ***1, **5, *10 percent level. Results are reported for two-step system GMM estimator. The figures reported for Hansen test and Arellano-Bond test are the p-values. The last two rows of the table report the p-values of the tests of coefficients' equality (we can reject the hypothesis that the coefficients on domestic and foreign size are equal, and the hypothesis that the coefficients on domestic and foreign openness are equal.

Source: own elaboration

Results reported in Columns 1a and 1b of Table 8 consider inverse measure of human capital, concerning both Polish and foreign sectors. We use the share of hours worked by low-skilled persons engaged in total hours worked in a given sector and country, coming from the EUKLEMS and denoted as LS. The low skilled are defined here on the base of educational attainment and represent persons with primary education only.[14] The lower the LS, the higher sectoral human capital level should be, thus at least the relationship between

[14] The adoption of a direct measure of human capital - the share of high skilled persons engaged in total hours worked in a given sector – can be problematic due to international differences in educational systems concerning higher stages of education. Hence, cross country comparability is more direct in case of a measure taking into account persons with primary education only (more homogeneous across countries).

our inverse measure of domestic skill intensity and productivity growth is expected to be negative. Such an impact is confirmed in case of human capital in Polish sectors (foreign one results to be insignificant), with the remaining conclusions staying robust.

As research and development proxy (in case of Poland, due to problems with gathering full set of such data for all the partner countries) we employ expenditure on R&D as a share of VA. In order to account for possible horizontal spillovers we use country (not sector) specific value coming from ANBERD (2009). It shall reflect absorption capacity of the Polish economy, potentially fostering productivity gains due to integration process.

Table 9. Robustness check (IV) – inclusion of wage into the long run empirical specification

dependent variable: growth of relative labour productivity: $\Delta ln(rel\_prod)_{PL,p,i,t}$,
where *PL*- Poland, *p*- partner, *i*- sector, *t*- time

	Trade =Import				*Trade =Export*		
	(1a)	(2a)	(3a)	(4a)	(1a)	(2a)	(3a)
$ln(rel\_prod)_{PL,p,i,t-1}$	-0.069***	-0.072***	-0.070***	-0.077***	-0.078***	-0.079***	-0.059***
	[0.001]	[0.002]	[0.001]	[0.002]	[0.002]	[0.002]	[0.002]
$\Delta ln(size)_{PL,i,t}$	0.982***	0.984***	0.987***	0.897***	0.965***	0.977***	0.888***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.001]	[0.002]	[0.002]
$ln(size)_{PL,i,t-1}$	0.030***	0.038***	0.033***	0.020***	0.032***	0.045***	0.017***
	[0.001]	[0.001]	[0.001]	[0.002]	[0.001]	[0.001]	[0.001]
$\Delta ln(size)_{p,i,t}$	-0.782***	-0.801***	-0.789***	-0.730***	-0.777***	-0.787***	-0.761***
	[0.002]	[0.003]	[0.003]	[0.004]	[0.003]	[0.002]	[0.003]
$ln(size)_{p,i,t-1}$	-0.011***	-0.012***	-0.012***	-0.010***	-0.012***	-0.012***	-0.004***
	[0.000]	[0.001]	[0.001]	[0.001]	[0.000]	[0.000]	[0.001]
$\Delta ln(trade)_{PL,i,t}$	0.167***	0.145***	0.155***	0.204***	0.077***	0.049***	0.119***
	[0.002]	[0.003]	[0.002]	[0.003]	[0.002]	[0.002]	[0.003]
$ln(trade)_{PL,i,t-1}$	0.017***	0.004**	0.008***	0.025***	0.023***	0.007***	0.018***
	[0.001]	[0.001]	[0.001]	[0.002]	[0.001]	[0.001]	[0.001]
$\Delta ln(trade)_{p,i,t}$	-0.026***	-0.014***	-0.021***	-0.051***	-0.037***	-0.032***	-0.033***
	[0.001]	[0.001]	[0.001]	[0.003]	[0.002]	[0.001]	[0.002]
$ln(trade)_{p,i,t-1}$	-0.022***	-0.016***	-0.018***	-0.036***	-0.018***	-0.017***	-0.015***
	[0.001]	[0.001]	[0.001]	[0.002]	[0.001]	[0.001]	[0.001]
$ln(wage)_{PL,i,t-1}$	0.035***	0.032***	0.033***	0.029***	0.047***	0.026***	0.024***
	[0.002]	[0.001]	[0.002]	[0.003]	[0.002]	[0.002]	[0.002]
$ln(wage)_{p,i,t-1}$	-0.021***	-0.020***	-0.021***	-0.025***	-0.024***	-0.022***	-0.022***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
$\Delta ln(interm\_trade)_{PL,i,t}$		0.043***				0.053***	
		[0.002]				[0.001]	
$ln(interm\_trade)_{PL,i,t-1}$		0.005***				0.004***	
		[0.001]				[0.001]	
$\Delta ln(interm\_trade)_{p,i,t}$		-0.004*				0.001**	
		[0.002]				[0.000]	
$ln(interm\_trade)_{p,i,t-1}$		0.002*				0.005***	
		[0.001]				[0.000]	

Table 9. Cont.

	Trade =Import				*Trade =Export*		
	(1a)	(2a)	(3a)	(4a)	(1a)	(2a)	(3a)
$\Delta ln\ (OutsIndex)_{PL,i,t}$			[0.029***] [0.002]				
$ln\ (OutsIndex)_{PL,i,t-1}$			0.004*** [0.000]				
$\Delta ln(FDI\_in)_{PL,i,t}$				0.009*** [0.002]			-0.002*** [0.000]
$ln(FDI\_out)_{PL,i,t-1}$				0.00 [0.001]			-0.002*** [0.000]
AR(1)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AR(2)	0.365	0.275	0.303	0.149	0.272	0.251	0.211
Hansen test	0.99	0.99	0.99	0.99	0.99	0.99	0.99
N	3030	3021	3030	2065	3034	3030	1701

Notes: all computations made using XTABOND2 for StataSE 11. Partner's country/sector fixed effects and time effects included in all regressions. All explanatory variables treated as endogenous and instrumented by their own lags. Standard errors in parentheses. Statistically significant at ***1, **5, *10 percent level. Results are reported for two-step system GMM estimator. The figures reported for Hansen test and Arellano-Bond test are the p-values.

Source: own elaboration

Finally, as suggested in Chen, Imbs and Scott, (2009), we control the long run specification of the model by the inclusion of the information on real wages (in prices from 1995 and converted with nominal exchange rate). In order to calculate average sector level wages both for Polish and partner countries' sectors, we used the information on labour compensation and hours worked from the EUKLEMS. Results reported in Table 9 suggest positive relationship between relative productivity in Polish sectors and domestic wages, and the negative relationship with foreign wages. Other key findings concerning the impact of openness and sectors' size remain stable.

In conclusion, none of the above changes in the estimated model resulted in significant changes in the obtained results.

5

Conclusions

Despite the ongoing integration process and general opening of the Polish economy, relative productivity levels in manufacturing in Poland remain lower than the European standards. Real value added in PPS terms in Polish manufacturing in 2006 was equal to 81% of EU15 average, compared to only 39% in 1995. Hence, the process of relative productivity convergence takes place and it seems important to assess the importance of integration with the EU in stimulating productivity growth in Poland. Examination of disaggregated data confirms great heterogeneity existing between productivity trends in distinct sectors which suggests the appropriateness of sector level analysis.

Main aim of this paper was to address the impact of integration forces (focusing on trade) on labour productivity growth in Polish manufacturing sectors, in a setting allowing for tracing bilateral productivity differentials between valued added per hour worked in Poland and in its trade partners. We treat such bilateral differences in productivity levels as a measure of relative distance from the technological frontier between Poland and other countries in the EU. We focus on 12 manufacturing activities within the period of time 1995-2006 (thus covering the years of major trade integration of Poland with the EU markets). As partners we consider all current EU members states apart from Bulgaria and Romania (due to data constraints).

We find that trade integration, influencing the degree of openness of single sectors, can be considered among positive determinants of relative labour productivity growth in Polish manufacturing. Using a version of error correction model, we have assessed separately the impact of export and import openness, taking into account both short run and long run effects. Our main results suggest that not only changes in openness *per se* are important for domestic productivity developments but relative position *vis-à-vis* partner countries is crucial. While increase in openness of domestic sector can exert positive effect of productivity growth, major openness of the same sector in partner countries influences negatively our relative productivity. Therefore, an important conclusion is that in order to stimulate productivity growth process at home, *relative* domestic openness must rise. We have checked if the direction of flows is important. The influence of imports and exports is similar. Findings concerning the influence of outsourcing practises and FDI on productivity are less strong.

Recent theoretical considerations suggest that trade effects on productivity are conditional upon the size of the markets. Indeed, examining the case of Polish manufacturing, we find robust evidence that growth of domestic sectors is associated with rising productivity growth at home, while the expansion of manufacturing sectors in foreign countries is linked negatively to our productivity growth. Thus, again, changes in relative size of sectors matter.

To sum up, our study confirms the empirical findings based on recent models of procompetitive effects of trade and based on different than ours sets of data. By opening up Polish manufacturing sectors seem to have benefited from integration in terms of productivity gains and movements towards the technological frontier with respect to trends in other EU countries.

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Appendix

Table A1. List of manufacturing sectors included into the analysis

Description	EUKLEMS code
Food, beverages and tabacco	(15t16)
Textiles, leather and footwear	(17t19)
Wood and products of wood and cork	(20)
Pulp, paper, paper products, printing and publishing	(21t22)
Chemicals and chemical products	(24)
Rubber and plastics	(25)
Other non-metallic mineral products	(26)
Basic metals and fabricated metal products	(27t28)
Machinery, nec	(29)
Electrical and optical equipment	(30t33)
Transport equipment	(34t35)
Manufacturing n.e.c., recycling	(36t37)

Table A2. Correspondence table between industrial (EUKLEMS) and trade (UNComtrade – Ms Woertz) sectors

NACE Ms Woerz product code	Description	KLEMS code
151	Meat products	(15t16)
152	Fish and fish products	
153	Fruits and vegetables	
154	Vegetable and animal oils and fats	
155	Dairy products; ice cream	
156	Grain mill products and starches	
157	Prepared animal feeds	
158	Other food products	
159	Beverages	
160	Tobacco products	
171	Textile fibres	(17t19)
172	Textile weaving	
174	Made-up textile articles	
175	Other textiles	
176	Knitted and crocheted fabrics	
177	Knitted and crocheted articles	
181	Leather clothes	
182	Other wearing apparel and accessori	
183	Dressing and dyeing of fur; article	

191	Tanning and dressing of leather	
192	Luggage, handbags, saddlery and har	
193	Footwear	
202	Panels and boards of wood	
203	Builders' carpentry and joinery	(20)
204	Wooden containers	
205	Other products of wood; articles of	
211	Pulp, paper and paperboard	
212	Articles of paper and paperboard	(21t22)
221	Publishing	
222	Printing	
241	Basic chemicals	
242	Pesticides, other agro-chemical pro	
243	Paints, coatings, printing ink	
244	Pharmaceuticals	(24)
245	Detergents, cleaning and polishing,	
246	Other chemical products	
247	Man-made fibres	
251	Rubber products	(25)
252	Plastic products	
261	Glass and glass products	
262	Ceramic goods	
263	Ceramic tiles and flags	
264	Bricks, tiles and construction prod	(26)
265	Cement, lime and plaster	
266	Articles of concret, plaster and ce	
267	Cutting, shaping, finishing of ston	
268	Other non-metallic mineral products	
271	Basic iron and steel, ferro-alloys	
272	Tubes	
273	Other first processing of iron and	
274	Basic precious and non-ferrous meta	(27t28)
281	Structural metal products	
282	Tanks, reservoirs, central heating	
283	Steam generators	
286	Cutlery, tools and general hardware	
287	Other fabricated metal products	
291	Machinery for production, use of m	
292	Other general purpose machinery	
293	Agricultural and forestry machinery	(29)
294	Machine-tools	
295	Other special purpose machinery	
296	Weapons and ammunition	
297	Domestic appliances n. e. c.	
300	Office machinery and computers	
311	Electric motors, generators and tra	

312	Electricity distribution and contro	(30t33)
313	Isolated wire and cable	
314	Accumulators, primary cells and pri	
315	Lighting equipment and electric lam	
316	Electrical equipment n. e. c.	
321	Electronic valves and tubes, other	
322	TV, and radio transmitters, apparat	
323	TV, radio and recording apparatus	
331	Medical equipment	
332	Instruments for measuring, checking	
334	Optical instruments and photographi	
335	Watches and clocks	
341	Motor vehicles	(34t35)
342	Bodies for motor vehicles, trailers	
343	Parts and accessories for motor veh	
351	Ships and boats	
352	Railway locomotives and rolling sto	
353	Aircraft and spacecraft	
354	Motorcycles and bicycles	
355	Other transport equipment n. e. c.	
362	Jewellery and related articles	(36t37)
363	Musical instruments	
364	Sports goods	
366	Miscellaneous manufacturing n. e. c	
Total	Total Trade	TOT

Table A3. List of countries and adopted abbreviations

EU25
AUT Austria
BLX Belgium and Luxembourg
DNK Denmark
ESP Spain
FIN Finland
FRA France
GER Germany
GRC Greece
IRL Ireland
ITA Italy
NLD Netherlands
PRT Portugal
SWE Sweden
UK United Kingdom
CZE Czech Republic

CYP Cyprus
EST Estonia
HUN Hungary
LVA Latvia
LTU Lithuania
MLT Malta
POL Poland
SVK Slovak Republic
SVN Slovenia

Table A4. Unit root tests

variable	W-statistics	first difference	W-statistics
$ln(rel\_prod)_{PL,p,i,t-1}$	8.87 (1.00)	$\Delta ln(rel\_prod)_{PL,p,i,t}$	-15.6 (0.00)
$ln(size)_{PL,i,t}$	18.9 (1.00)	$\Delta ln(size)_{PL,i,t}$	-6.9 (0.00)
$ln(size)_{p,i,t}$	5.54 (1.00)	$\Delta ln(size)_{p,i,t}$	-13.2 (0.00)
$ln(trade\_imp)_{PL,i,t}$	-7.5 (0.00)	$\Delta ln(trade\_imp)_{PL,i,t}$	-10.1 (0.00)
$ln(trade\_imp)_{p,i,t}$	-1.3 (0.11)	$\Delta n(trade\_imp)_{p,i,t}$	-15.9 (0.00)
$ln(trade\_exp)_{PL,i,t}$	10.8 (1.00)	$\Delta ln(trade\_exp)_{PL,i,t}$	-6.9 (0.00)
$ln(trade\_exp)_{p,i,t}$	-1.3 (0.10)	$\Delta n(trade\_exp)_{p,i,t}$	-17.5 (0.00)
$ln(FDI\_in)_{PL,i,t-1}$	-1.11 (0.14)	$\Delta ln(FDI\_in)_{PL,i,t-1}$	-7.71 (0.00)
$ln(FDI\_out)_{PL,i,t-1}$	*	$\Delta ln(FDI\_out)_{PL,i,t-1}$	*

Notes: Im-Pesaran-Shin reports values for the W-statistic corresponding to the null hypothesis that there is a unit root that is individual to each cross section, p-values in brackets.

* insufficient number of observations

Source: own elaboration