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THE ROLE OF TRADE IN INTRA- INDUSTRY PRODUCTIVITY GROWTH - THE CASE OF OLD AND NEW EUROPEAN UNION COUNTRIES (1995-2007)

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THE ROLE OF TRADE IN INTRA-INDUSTRY PRODUCTIVITY GROWTH - THE CASE OF OLD AND NEW EUROPEAN UNION COUNTRIES (1995-2007)

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Abstract:

The purpose of this paper is to evaluate the role of trade in productivity growth in a sample of 30 sectors in 25 EU countries in the period of rapid East-West integration. Shift-share analysis is used to show that changes in value added per hour worked in these countries appear to be mainly due to positive developments (rising productivity) within single industries and only to a lower extent result from a shift towards higher productivity activities. Trade is found to be an important positive determinant of intra-industry productivity growth in European countries. Exports and imports alike can be associated with efficiency gains, but intermediate good exchange and trade with New Member States exert a particularly strong influence on intra-industry productivity growth in the EU.

JEL: F14, F16, O47

Keywords: *productivity, trade, shift share analysis, European Union*

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1. Introduction

Productivity growth in the EU still remains a considerable concern, especially in the light of unrealised European ambitions to become “the most competitive and dynamic knowledge-based economy in the world”, as expressed in the ‘Lisbon Agenda’, set out in 2000 but not achieved so far. This was replaced by the EU’s ‘Europe 2020’ strategy to “become a smart, sustainable and inclusive economy” with high productivity being one of the targets (along with high employment and social cohesion). The truth is that the EU lags behind its historical reference point – the US – even if we take into account the fact that in Western European countries some productivity convergence took place until the mid 1990s (especially in the years 1950-1973, but also afterwards, when productivity growth in Europe was less rapid than before but still more dynamic than in the US). The European slowdown after 1995 is believed to have been caused mainly by a less dynamic emergence of the knowledge economy in Europe than in the US (van Ark et al., 2008). Consequently, in 2009 hourly labour productivity in the US was almost 34% higher than in EU countries (EU27, data from Eurostat), and the gap has increased by 4 percentage points since 1995.

The recent EU enlargements dramatically changed the overall productivity levels of the union, mainly due to the accession of countries (New Member States - NMS) with considerably lower levels of labour productivity than the EU-15. In 2004, the year of the biggest enlargement ever, when ten new countries joined the EU, labour productivity per hour worked (based on GDP, PPS, data from Eurostat) ranged from only 42% of the EU-15 average in Estonia to 125% in Belgium and 158% in Luxembourg. In 2009, hourly labour productivity in the NMS was at the level of 56% of the EU-15 typical value, which when compared to only 42% in 1997 indicates that some process of productivity convergence did however take place within the EU.

Several features may determine productivity growth patterns, from beta convergence type mechanisms based on technology adoption, to endogenous forces based on innovation, R&D (Cohen and Levinthal, 1989) or human capital (Nelson and Phelps, 1966; Benhabib and Spiegel, 1994), to trade-based productivity gains due to enhanced competition, learning effects and technology spillovers

(Helpman, 1997). In particular, recent ‘new-new trade theory (see the influential contribution by Melitz, 2003; as well as Bernard et al., 2007; and Melitz and Ottaviano, 2008¹) has extended ‘new’ trade theory (drawing on Krugman, 1980) views on patterns of intra-industry trade and the channels through which trade can stimulate productivity, thanks to the inclusion of firm heterogeneity. Apart from facilitating the transfer of knowledge and technology diffusion across countries (Eaton and Kortum, 1999 and 2001), trade is now believed to stimulate firms to behave more competitively. Not only are exporting firms usually more productive than non-exporters functioning within the same industries (self-selection), but more exposure to trade (for example through trade liberalization) also provokes a reallocation of resources across firms in the same industry, while at the same time raising industry productivity (Wagner, 2007).

In the specific case of the EU, the recent two decades have been characterised by major changes linked to the opening towards the countries of Central and Eastern Europe (CEECs), mainly through trade and political integration. Along with the integration process, the degree of trade openness of the EU as a whole has risen: according to the World Bank’s WDI,² in the early 1990s the EU’s ratio of total trade to GDP was close to 55%; it started to increase systematically in the mid 1990s when the Europe Agreements between the EU-15 countries and the CEECs were signed; and finally reached the level of 80% in 2008 (thus, after the two EU enlargements in 2004 and 2007).³ The nature of trade also changed as a result of more intense outsourcing practices and fragmentation of production across Europe, mainly due to the considerable cost advantage of CEECs and falling trade costs as a result of the integration process (Martin, 2006).

The main aim of this paper is to empirically analyze the role that trade has played in promoting intra-industry productivity growth in the EU countries in the years of dynamically changing relations

¹ Chen et al. (2009) estimate a version of Melitz and Ottaviano’s (2008) theoretical model using industry-level data on 7 EU-15 countries (Belgium, Germany, Denmark, Spain, France, Italy and the Netherlands) for the years 1989-1999. They find evidence that, at least in the short run, trade openness exerts a stimulating effect on productivity, while prices and mark-ups tend to fall due to the competitive effect of major exposure to trade.

² World Development Indicators.

³ A drop in the EU’s openness ratio to 70% was registered in 2009, due to the global crisis.

between the ‘old’ EU members (the EU-15 countries) and the ‘candidate’ – then ‘new’ – members of the EU.

The empirical evidence of the effects of international trade on growth and productivity based on cross-country panel studies (due to our panel data approach, we leave aside country-specific studies) is vast.⁴ However, it seems that there exists a gap concerning empirical panel-data analysis of the productivity-trade relationship that refers to the enlarged EU and simultaneously takes into account both the former EU-15 countries and the NMS and trade flows between them. Recent studies concerning productivity growth in bigger groups of European countries focus on the sources of poor productivity developments in EU-15 sectors compared to the US (van Ark et al., 2008; Mc Morrow et al. 2010). However, a lack of evidence concerning the whole integrated EU (after the enlargements of 2004 and 2007), including the NMS, is noticeable.⁵

Consequently, this study contributes to the existing literature on the effects of European integration on productivity growth in several ways. First of all, we consider a large sample of EU countries, both ‘old’ and ‘new’ Member States, within a homogeneous setting allowing us to analyse the trade-productivity growth nexus in the period of rapid East-West integration. Secondly, drawing on an industry-level database (EUKLEMS, release: November 2009)⁶, we consider not only overall productivity growth, but also separately assess the importance of inter- and intra-industry developments concerning productivity upgrading and efficiency gains. Thirdly, we distinguish not only between the heterogeneous effects of exports and imports, but also take into account the typology of partner countries and goods traded. By doing this, we can discriminate between various responses of intra-

⁴ A first wave of research, generally confirming a positive impact of trade on growth and productivity encompasses (among others): Sachs and Werner (1995); Frankel and Romer (1999), Ales and Glaeser (1999), and Alesina et al., 2000. After criticism on the grounds of measurement problems and econometric misspecifications (e.g. Rodriguez and Rodrik, 2001), the debate was re-opened (Wacziarg, 2001; Alcalá and Ciccone, 2004; Wacziarg and Welch, 2008). The emergence of ‘new-new trade theory’ (Melitz 2003, Melitz and Ottaviano, 2008), emphasizing firm heterogeneity, boosted research based on firm-level data (Wagner, 2007 provides a survey of the first wave of firm-level evidence on the exports-productivity nexus).

⁵ Past research concerning CEECs focused on growth processes in transition (in which trade have played a positive role, as shown in Dawson and Hubbard, 2004). The centre of attention of recent NMS-specific studies has been productivity convergence and the role played, for example, by FDI flows, but not openness (Bijsterbosch and Kolasa, 2010).

⁶ In the meantime, a WIOD (World Input-Output Database, April 2012), providing an update and extension of EUKLEMS, has been released. This paper presents results based on the EUKLEMS data, while in the last section we provide a discussion of possible extensions of the analysis through the use of WIOD data.

industry productivity to trade with the EU-15 and with the NMS, and at the same time account for the differences in the productivity effects of intensified overall exchange of goods and enhanced trade in intermediate goods (linked to outsourcing) as discussed in Keller (2000).

The rest of the paper is structured as follows: in Section 2, we describe our industry-level data along with emerging descriptive evidence on productivity upgrading and trade patterns in the EU since the mid 1990s. Overall labour productivity growth is broken down into contributions resulting from intra-industry efficiency gains raising productivity (the dominating component) and inter-industry movements of resources (labour) in the form of shift effects (far less important). In Section 3, we present the results of the empirical model to assess the link between intra-industry productivity growth and trade, together with a description of robustness checks and control estimations. Our findings confirm that in our sample of EU-25 countries greater trade openness has indeed played a positive role in promoting labour productivity growth (especially in stimulating intra-industry positive productivity developments), but the strength of this effect depends on the group that the partners belong to and the typology of goods traded: trade with the NMS and trade in intermediate goods are particularly strong determinants of intra-industry productivity growth. Section 4 concludes.

2. Data and methodological issues

2.1 Data sources

The main problems related to the empirical exploration of industrial structures are usually linked to the relatively limited availability of industry-level statistics, especially for larger samples of countries. We overcome this limit by using the latest release of the EUKLEMS Growth and Productivity Accounts database (we used the November 2009 release)⁷, the comparable disaggregated industrial statistics (NACE) from which are employed in the productivity analysis of our sample of

⁷ Release November 2009 is an update of the earlier releases of EUKLEMS (March 2007, March 2008) and contains time series from 1970 (mainly for the EU-15 countries) or 1995 (NMS) up to 2007 (or 2006). Further extension (a more detailed industry breakdown of output and employment variables) is available in the March 2011 update. See O'Mahony and Timmer (2009) for an overview of the EUKLEMS project. Detailed information on sources and methods can be found at: www.euklems.net.

European countries. The time span is restricted by data availability and in the end our study covers the years 1995-2007⁸. In order to be able to compare productivity levels across countries, for those not belonging to the euro zone we use euro/national currency exchange rates from Eurostat. Real productivity is computed as value added per hour worked, and deflated by value-added price indices (also from EUKLEMS), using 1995 as the base year. Comparable statistics, which we use for the calculation of the intra-industry component of productivity growth in all the countries in our sample (EU-15 and NMS-10⁹), are available for 30 sectors, covering practically all the economy and including 13 manufacturing industries plus several market and non-market services (Table A1 in the Appendix).

Trade data comes from the UNComtrade database accessed through WITS¹⁰. Trade statistics were originally reported in current US\$. Thus, to calculate trade penetration ratios (VA/imp or VA/exp) we use annual euro-US\$ exchange rates from the IMF. In order to account for the heterogeneous effects of the two flows, we examine exports and imports separately, additionally distinguishing between flows to/from the following groups of partners: the rest of the world, the EU-25, the EU-15, the NMS-10. Furthermore, we compute separate measures of trade penetration concerning only trade in intermediate goods, in particular treating the ratio of imports of these goods to added value as a proxy for outsourcing activity (see Molnar et al., 2007)¹¹. As far as additional control variables are concerned, R&D expenditure ratios (as a % of GDP) come from Eurostat. As a measure of human capital, we use the tertiary education enrolment ratio expressed as a percentage of the

⁸ For Poland, Portugal and Slovenia 1995-2006, due to the unavailability of statistics concerning the year 2007.

⁹ In the paper, the EU-25 group is composed of the EU15 and the NMS-10. Throughout the study the following abbreviations have been adopted: EU-15 ('old' EU countries) - Austria (AUT), Belgium and Luxembourg (BLX), Denmark (DNK), Spain (ESP), Finland (FIN), France (FRA), Germany (GER), Greece (GRC), Ireland (IRL), Italy (ITA), Netherlands (NLD), Portugal (PRT), Sweden (SWE), United Kingdom (UK). NMS-10 ('new' EU countries) - the Czech Republic (CZE), CYP (Cyprus), EST (Estonia), Hungary (HUN), LVA (Latvia), LTU (Lithuania), MLT (Malta), Poland (POL), Slovak Republic (SVK) and Slovenia (SVN).

¹⁰ The Commodity Trade Statistics Database (UNComtrade, United Nations Statistics Division) is available through World Integrated Trade Solutions (www.wits.worldbank.org/witsweb).

¹¹ In the first step, on a basis of 5-digit trade statistics (SITC rev.3) we identify goods that are classified as intermediates subject to outsourcing practices (according to the list of goods in Molnar et al., 2007 p.69-70). Next, we separately sum the values of imports and exports of these goods for each year and reporting country in our sample and relate it to the reporting country's added value. A similar procedure is repeated taking into account flows of intermediates to/from: the rest of the world, the EU-25, the EU-15, and the NMS10. The construction of other measures of outsourcing based on input-output tables (unavailable for the whole sample of countries at the time we performed our analysis) is now possible with the use of WIOD statistics.

population aged over 15 (combining data on enrolment from UNESCO and population data from the Penn World Table).

2.2 Shift-share analysis of productivity growth

In order to calculate the relative importance of within-industry developments in total labour productivity growth we apply a shift-share decomposition, according to which total labour productivity growth is broken down into contributions resulting from intra-industry efficiency gains raising productivity and inter-industry movements of resources (labour) in the form of so-called dynamic and static shift effects (Fagerberg, 2000, p. 401):

$$\left(\frac{\Delta P_{iT}}{P_{i0}} \right) = \sum_{j=1}^n \left[\underbrace{\frac{s_{ijt_0} \Delta P_{ijt}}{P_{ijt_0}}}_{\text{intra-industry effect (} Pgr^{Intra} \text{)}} + \underbrace{\frac{P_{ijt_0} \Delta s_{ijt}}{P_{ijt_0}}}_{\text{static shift effect (} Pgr^{StatShift} \text{)}} + \underbrace{\frac{\Delta P_{ijt} \Delta s_{ijt}}{P_{ijt_0}}}_{\text{dynamic shift effect (} Pgr^{DynShift} \text{)}} \right] \quad (1)$$

where P indicates real labour productivity in terms of value added per hour worked, i refers to countries and j to sectors, s is the share of employment in a given sector out of the total employment in country i and T denotes the time period (t_0, t) .

Shift effects reflect the capacity of a country to move its labour force towards industries with higher levels of productivity (static shift effect – $Pgr^{StatShift}$) or the ability to move it towards industries with rapid productivity growth (dynamic shift effect – $Pgr^{DynShift}$)¹². If the so-called ‘structural bonus hypothesis’ (Timmer and Szirmai, 2000) is confirmed, then in the course of growth the shift in labour towards sectors with rising productivity contributes positively to overall productivity upgrading, which reflects the positive effects of a structural change.¹³ However, empirical evidence (Fagerberg, 2000¹⁴; Maudos et al., 2008¹⁵; Timmer and Szirmai, 2000¹⁶; Peneder, 2003¹⁷) points instead to the conclusion

¹² The dynamic shift effect, being an interaction term, is usually positive if fast growing sectors (in terms of productivity) increase their share of total employment while it is negative if industries with fast growing productivity do not manage to maintain their shares of total employment. Of course, the dynamic shift effect can also be positive if both changes (in productivity and in the employment share) are negative.

¹³ On the contrary, according to Baumol's (1967) view, structural change can have a negative impact on aggregate growth if employment shares shift away from progressive industries to those with a lower pace of productivity growth.

¹⁴ Analysis based on a sample of 39 countries over the years 1973-1990.

¹⁵ Comparative analysis of the EU-15 versus the US (1977-2004).

¹⁶ Analysis based on a sample of four Asian countries (1963-1999).

that it is the internal effect of productivity growth (the intra-industry growth effect, here: Pgr^{Intra}) that tends to dominate over the contribution of inter-industry movements to productivity growth. The importance of cross-industry shifts in driving productivity growth is believed to be quite small. Moreover, our analysis aims to test ‘new-new’ trade theories suggesting that trade can stimulate intra-industry productivity developments through enhanced competition. Consequently, we focus on the intra-industry component of productivity growth (Pgr^{Intra}) obtained as one of the components decomposed from productivity growth (2).

In Table 1 we show the aggregate results of the decomposition of productivity growth in our country groups, along with the relative (as a percentage of total productivity growth) contribution of the intra-industry productivity growth effect and shift effects.

Taking into account the whole sample of countries (EU-25) in the years 1995-2007, value added per hour worked rose by almost 55% – this rise was due to a dominating intra-industry effect, and to a much lower extent resulted from an increase in the share of higher productivity sectors in total employment (note the positive, but low, static shift effect – column C), while the dynamic shift effect was negative (column D). Comparing the two groups of countries, on average the NMS-10 registered a more positive change in total productivity (a rise of 84.6% between 1995 and 2007) than the EU-15 countries (a rise of 25%). In both groups of countries total productivity growth was driven by intra effects. This means that within the years 1995-2007 changes in value added per hour worked were due mainly to positive developments (rising productivity) within single sectors, while shift effects played a much less important role.¹⁸ Moreover, the negative dynamic shift effect indicates that reallocation of the labour force towards sectors with a lower relative growth in productivity contributed negatively to the productivity growth record. Such a negative effect was stronger in the EU-15 countries than in the NMS-10.

¹⁷ Analysis based on a sample of EU-15 countries (various years across the 1980s and 1990s), USA (1987-1997) and Japan (1990-1999).

¹⁸ Unfortunately, the unavailability of industry-level statistics concerning the NMS prior to the year 1995 does not allow us to consider productivity developments linked to the structural change that took place in these countries immediately after their system transformation (1989/1990). On the other hand, NMS statistics prior to the year 1995 could be characterized by significant noise in the data due to severe recessions and disruption of economic structures. We thank the referee for pointing this out.

Table 1. Decomposition of hourly labour productivity growth, (EU25, EU15, NMS10, total growth rate 1995-2007)

		Total Productivity growth $\Delta P/P$ [A]	Intra-industry effect P_{gr}^{Intra} [B]	Shift effect	
				$P_{gr}^{StatShift}$ [C]	$P_{gr}^{DynShift}$ [D]
EU-25	total growth rate 1995-2007 [%]	54.9	56.1	4.6	-5.8
	as % of total productivity growth	100.0%	102.2%	8.5%	-10.6%
EU-15	total growth rate 1995-2007 [%]	25.2	28.5	2.1	-5.4
	as % of total productivity growth	100.0%	113.1%	8.3%	-21.4%
NMS-10	total growth rate 1995-2007 [%]	84.6	83.6	7.2	-6.3
	as % of total productivity growth	100.0%	98.9%	8.5%	-7.4%

Note: $A \sim B+C+D$ (eq.1)

Source: own elaboration based on data from EUKLEMS

In Table 2 we present intra-industry productivity developments and shift effects along with overall productivity growth in separate countries from the EU-25 group over the years 1995-2007 (with the exception of Portugal, Poland and Slovenia, for which statistics are only available up to the year 2006). The countries are ranked in ascending order within the two groups, according to their overall productivity growth in the period analysed.

Productivity changes differ greatly across countries, with the Baltic States, Slovakia and the Czech Republic being the best performers (for example in the years 1995-2007 in Lithuania real value added per hour worked rose by more than 200%). In all the NMS-10 countries and in eight of the EU-15 economies the impact of the static shift effect was positive, which reflects some ability to move employment towards higher productivity activities. This was not the case in such EU-15 countries as Italy, The Netherlands, Finland, Sweden and the UK, where labour shifted to less efficient sectors and the static shift effect contributed negatively to overall productivity growth. Support for the 'structural bonus hypothesis' is weak, as the average interaction term (dynamic shift effect) is negative in all EU-15 countries and in six of the NMS-10: this reflects a general lack of ability to reallocate the labour force towards sectors with rapid productivity growth. Only Cyprus, Malta and the Czech Republic managed to use this channel to promote productivity gains.

Table 2. Decomposition of hourly labour productivity growth, (EU25 countries, total growth rate 1995-2007*)

country	Total Productivity growth [%] $\Delta P/P$ [A]	Intra-industry effect [%] Pgr^{Intra} [B]	Shift effect [%]	
			$Pgr^{StatShift}$ [C]	$Pgr^{DynShift}$ [D]
EU-15:				
ITA	5.8	9.0	-0.2	-3.1
ESP	7.5	7.7	8.5	-8.7
DNK	7.7	9.3	1.0	-2.6
BLX	12.1	13.6	2.0	-3.6
NLD	21.1	27.1	-2.3	-3.7
FRA	21.9	24.7	0.0	-2.8
PRT	22.9	28.3	1.1	-6.5
GER	24.5	23.6	5.0	-4.1
AUT	24.6	27.8	2.8	-6.0
GRC	29.1	19.9	15.3	-6.1
FIN	38.6	45.4	-1.9	-4.8
IRL	47.4	56.7	2.0	-11.3
SWE	48.9	59.1	-0.5	-9.7
UK	53.3	59.5	-1.1	-5.1
NMS-10:				
HUN	8.6	3.9	4.7	0.0
CYP	30.3	21.6	7.4	1.3
MLT	38.7	30.3	7.1	1.4
POL	40.0	42.0	4.2	-6.3
SVN	57.0	44.2	25.0	-12.1
CZE	91.7	84.7	4.0	3.0
LVA	107.3	107.8	9.5	-10.0
SVK	118.9	138.7	0.4	-20.2
EST	140.8	150.4	6.0	-15.7
LTU	212.4	212.8	3.7	-4.1

Notes:

*PRT, POL and SVN: 1995-2006 due to data availability

A~B+C+D

Source: own elaboration based on data from EUKLEMS

Additionally, we show annual evidence of productivity growth and its components in single EU countries (Table 3). On average, in the period analysed hourly labour productivity rose by 1.9% per year in the EU-15 economies (with intra-industry productivity growth equal to 2.03%) and by 5% in the NMS-10 (with intra-industry productivity growth equal to 4.8%). Again, the dynamic shift effect turns out to be negative in the case of most countries, while the static shift effect is either negative or negligible.

To sum up, it seems that, apart from a few specific exceptions, productivity growth in EU countries after 1995 was driven by intra-industry developments.¹⁹ In the following part of the paper we will examine the role of trade liberalization in this aspect of productivity growth.

Table 3. Decomposition of hourly labour productivity growth, (EU25 countries, average of annual growth rates in the period 1995-2007*)

Country	Total Productivity growth [%] $\Delta P/P$ [A]	Intra-industry effect [%] Pgr^{Intra} [B]	Shift effect [%]	
			$Pgr^{StatShift}$ [C]	$Pgr^{DynShift}$ [D]
ITA	0.47	0.63	-0.10	-0.06
ESP	0.61	0.38	0.32	-0.09
DNK	0.63	0.70	-0.03	-0.05
BLX	0.96	1.02	0.03	-0.10
NLD	1.61	1.96	-0.31	-0.04
FRA	1.67	1.80	-0.09	-0.04
GER	1.84	1.63	0.26	-0.05
AUT	1.85	1.87	0.04	-0.06
PRT	1.90	1.90	-0.07	-0.08
GRC	2.18	1.73	1.18	-0.72
FIN	2.77	3.19	-0.37	-0.06
IRL	3.31	3.61	-0.11	-0.18
SWE	3.50	3.95	-0.31	-0.15
UK	3.81	4.04	-0.14	-0.09
EU-15 (average)	1.94	2.03	0.02	-0.13
HUN	0.93	0.79	0.54	-0.39
CYP	2.27	1.71	0.54	0.02
MLT	2.81	2.40	0.46	-0.05
POL	3.47	3.12	0.14	-0.08
SVN	4.19	2.68	1.30	-0.14
CZE	5.73	5.50	0.34	-0.11
LVA	6.49	6.55	0.77	-0.83
SVK	6.99	7.29	0.17	-0.47
EST	7.76	8.21	0.54	-0.99
LTU	10.07	10.14	0.80	-0.87
NMS-10 (average)	5.07	4.84	0.56	-0.39

Notes:

*PRT, POL and SVN: 1995-2006 due to data availability

$A \sim B+C+D$

Source: own elaboration based on data from EUKLEMS

¹⁹ Maudos et al. (2008), using the data from an earlier release of EUKLEMS and a similar methodology, compare productivity changes in the EU-15 and the US in the years 1977-2004 and conclude that the divergence between EU-15 and US productivity levels since the mid-1990s is due to lower productivity growth within sectors (intra-industry effects) in the EU-15 than in the US.

3. The role of trade in productivity growth and intra-industry productivity gains

3.1 Trade patterns concerning the EU-25 countries (1995-2007)

Since the mid-1990s, Europe has experienced major changes in trade patterns, mainly due to the opening of the EU-15 countries towards the economies from Central and Eastern Europe that eventually joined the EU in 2004 (and 2007). When their Association Agreements came into force, transition economies previously hidden behind the ‘Iron Curtain’ increased their degree of openness and managed to increase (i.e. double) their shares in trade with the EU-15 countries: in the years 1995-2007 the share of imports to the EU-15 countries from the NMS-10 (out of total EU-15 imports) rose from 2.3% to 4.9%, while the share of exports from the EU-15 (out of total EU-15 exports) to the NMS-10 rose from 3.3 to 6%. At the same time, the ratio of exports from the EU-15 to other EU-15 countries shrank from 64% to 53% of total exports. Figures relating to intra-EU-15 imports are very similar (all data from UNComtrade). Thus, trade reorientation took place within Europe and, moreover, the degree of openness of European countries underwent a change.

Figure 1 shows the evolution of trade openness in our sample of EU-25 countries (in order to capture the degree of trade penetration more precisely we calculate export and import shares with respect to the reporting country’s added value separately, and not the general degree of total trade openness with respect to GDP). The amounts refer to the EU-25 as reporters, while separate lines refer to trade with alternative groups of partners, starting from the most general formulation (trade with all partners – the rest of the world: WLD) and then restricted to trade with partners belonging to the EU-25, the EU-15 and the NMS-10. Analogically, Figure 2 presents penetration ratios concerning trade in intermediate goods only.²⁰

²⁰ For both figures the following formula, based on eq. (8) was adopted:

$$(trade_p / VA)_{EU25,T} = \frac{\sum_{k=1}^K trade_p_{EU25,kT}}{VA_{EU25,T}} \quad \forall p = \{WLD, EU25, EU15, NMS10\}$$

where T is the time period, k is the partner country belonging to the partners’ group $p = \{WLD, EU-25, EU-15, NMS10\}$ and $trade = \{exp_total, exp_interm, imp_total, imp_interm\}$ is the value of trade flow reported by the EU-25. exp_total and

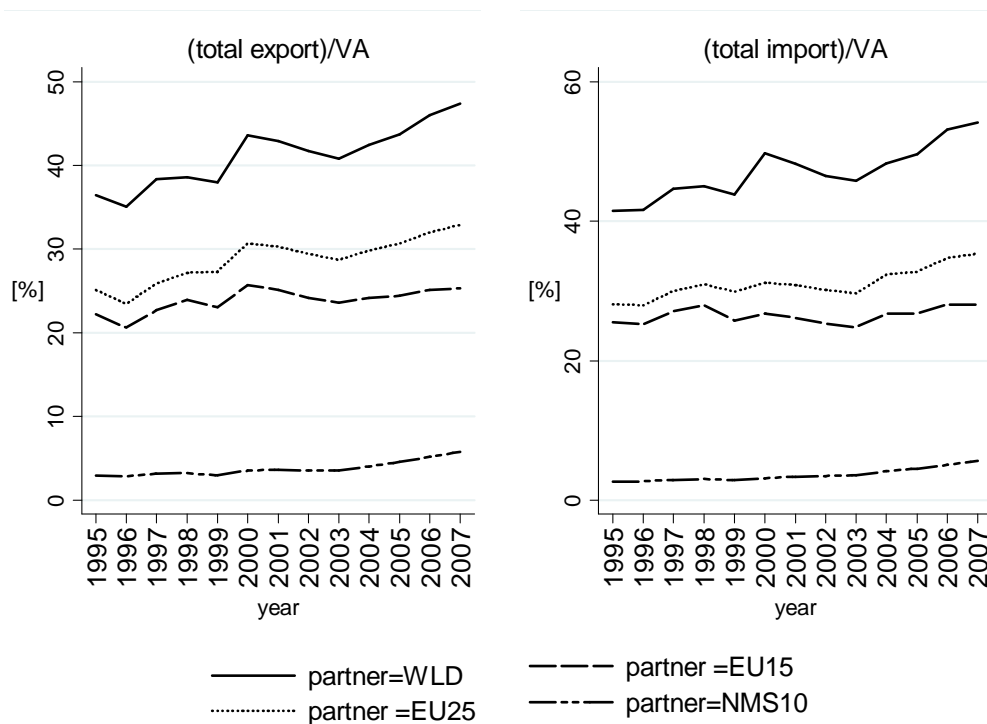


Figure 1. Trade openness (penetration ratios), all goods, EU25, 1995-2007

Source: own elaboration with UNComtrade data (WITS)

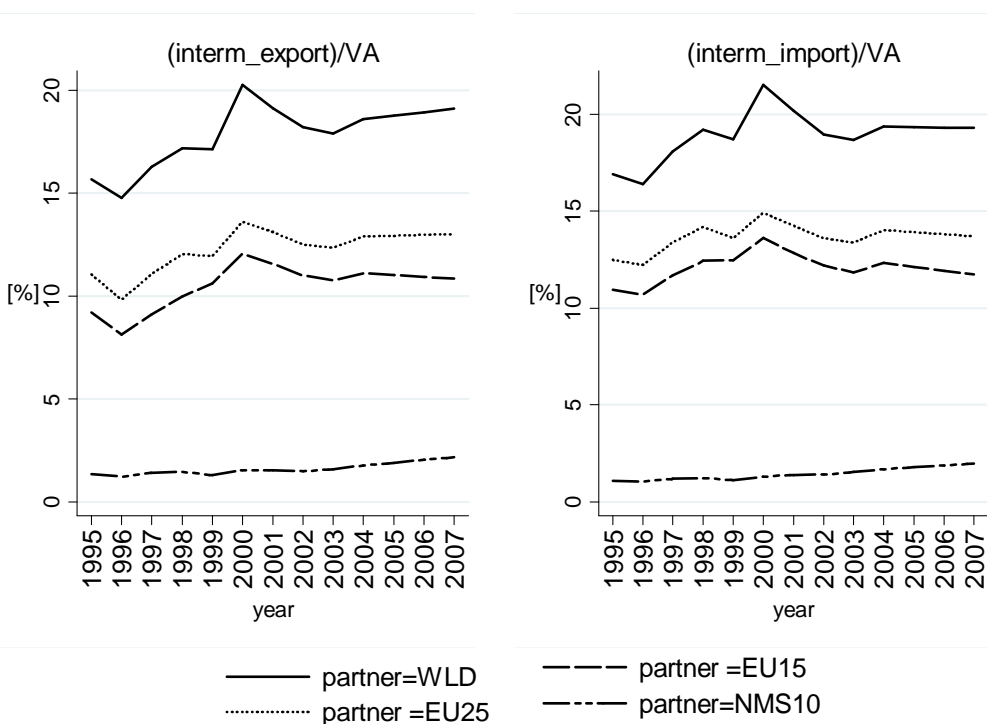


Figure 2. Trade openness (penetration ratios), intermediate goods, EU25, 1995-2007

Source: own elaboration with UNComtrade data (WITS)

imp_total denote flows of all types of goods, while *exp_interm* and *imp_interm* refer to flows of intermediate goods only. Observations for which reporter=partner were eliminated.

According to Figure 1, since 1995 the EU-25 have increased their degree of openness: the ratio of total exports (to the world) to VA rose from 37% in 1995 to 48% in 2007; however, a considerable drop in the export penetration ratio was registered in the years 2000-2003. Import penetration followed a very similar pattern (an increase from 43% in 1995 to 56% in 2007) but the share of VA due to imports was always higher than the share of VA due to exports. If we consider alternative partners, the ratios are obviously smaller due to the much lower volumes of trade. However, the ratios of exports destined to the EU-15 (or imports coming from the EU-15) to VA of reporting countries from the EU-25 group were always above 20% and remained quite stable. Penetration ratios referring to trade with the NMS-10 were considerably lower (below 6% in 2007) but rose constantly after 1995. This proves that the importance of the countries that joined the EU in 2004 has been constantly growing within the European trade network.

As can be seen from Figure 2, patterns of intermediate good trade openness are similar (this is true for flows in both directions) to those described above. When we consider general intermediate good trade openness (exports to/imports from the rest of the world with respect to VA) we notice that it rose dynamically until the year 2000, and then a considerable drop took place (probably due to the economic slowdown around that year) but started to rise again slowly after 2003. A similar pattern is confirmed if we consider trade only with partners from the EU-25 and EU-15 groups (here, however, penetration ratios slightly declined after 2004). The trend is different, however, if we take into account intermediate good exchanges with New Member States. The ratios of both exports and imports of intermediate goods to/from NMS-10 countries, expressed with respect to the VA of the reporters from the EU-25, slowly but constantly rose over the period analysed and no drop was registered. This is a sign that almost immediately after the opening up towards countries from Central and Eastern Europe, the NMS-10 became important and stable partners in outsourcing practises for the whole EU.

3.2 Econometric estimation of the productivity-trade nexus

In order to derive our empirical specification, as a starting point we consider the economy-wide production function:

$$Y = F(A, K, H, L), \quad (2)$$

where Y (output) is a function of physical capital K , human capital H , labour input L and overall technology A . We assume a benchmark Hall and Jones (1999) Cobb-Douglas-type production function of the form

$$Y_{it} = A_{it} K_{it}^{\alpha} (Lh)_{it}^{\beta}, \quad (3)$$

where $\alpha > 0$, $\beta > 0$, $\alpha + \beta = 1$, i indexes countries, t denotes the time period and Lh is the ‘quality adjusted’ workforce: labour input L multiplied by the human capital parameter h . Eq. (3) can be easily transformed into

$$y_{it} = A_{it} k_{it}^{\alpha} h_{it}^{\beta}, \quad (4)$$

so that $y = Y/L$ reflects output per hour worked, $k = K/L$ is the capital-labour ratio and h reflects human capital quality. Taking logs of both sides and differentiating with respect to time yields an expression for the growth rate of y :

$$\frac{\dot{y}}{y} = \frac{\dot{A}}{A} + \alpha \frac{\dot{k}}{k} + \beta \frac{\dot{h}}{h}. \quad (5)$$

In order to achieve an estimable empirical model we are constrained, due to restricted data availability, to adopt a few simplifications²¹. In line with the beta convergence growth mechanism (Barro, Sala-i-

Martin, 2004, Ch.I), suggesting that countries lagging behind may grow faster, $\frac{\dot{y}}{y}$ is assumed to depend

(negatively) on the lagged relative distance from the technology frontier (*TechDist*). Following Romer (1990), $\frac{\dot{A}}{A}$ depends on the production of new ideas and is thus a function of domestic R&D activity

²¹ A similar approach to deriving an estimable empirical specification has also been adopted in industry-level studies of productivity (eg. Fillat Castejón and Wörz, 2011).

growth ($RDgr$). Changes in the capital to labour ratio (not observed directly²²) will be assumed to vary across time and countries and depend indirectly on other factors included in the model, while $\frac{\dot{h}}{h}$ is measured as growth in human capital ($HCgr$) proxied by tertiary education enrolment. Additionally, given the role played by trade in productivity growth and technology transfer (Cameron, 2005; Helpman, 1997; Keller, 2000) and our focus on intra-industry productivity effects in the spirit of the ‘new-new’ trade models (Melitz, 2003), the model is augmented by trade (T). Finally, we consider labour productivity growth as the function

$$\frac{\dot{y}}{y} = F(TechDist, RDgr, HCgr, T). \quad (6)$$

In line with decomposition (1), $\frac{\dot{y}}{y} = Pgr^{Intra} + Pgr^{StatShift} + Pgr^{DynShift}$. Given the evidence reported in Section 2.2, the intra-industry growth effect strongly dominates overall productivity growth in our sample of EU countries. Thus we substitute the intra-industry component²³ for the left-hand side variable and estimate the following equation:

$$Pgr^{Intra}_{it} = \beta_0 + \beta_1 TechDist_{it-1} + \beta_2 RDgr_{it} + \beta_3 HCgr_{it} + \beta_4 (trade - p / VA)_{it} + d_T + \varepsilon_{it}, \quad (7)$$

where i refers to countries and t to the time period (we use annual observations). Pgr^{Intra} denotes the intra-industry productivity growth (in %) obtained from total productivity growth by clearing out shift effects as in Eq (1). We assume that the EU-15 countries represent a higher technological level so $TechDist$ (distance from the productivity frontier) is measured as relative productivity (in terms of VA per hour worked) with respect to the EU-15 average (EU15=100%), so lower values of $TechDist$ reflect a greater distance from the European technological frontier²⁴. At the same time, this variable allows us to correct for cross-country heterogeneity concerning productivity levels. $RDgr$ is measured as the

²² The 2008 release of EUKLEMS provided capital data only for 11 EU countries (among which only 2 were NMS). Note that the recently released WIOD (2012) contains estimates of the capital stock for more countries, so future research can partly overcome this limitation.

²³ Additionally, (see the robustness check section) we consider total productivity growth as the left-hand side variable.

²⁴ In the robustness checks section we control for other measurements of the frontier.

growth rate of R&D spending (in %)²⁵, while $HCgr$ as the growth in the tertiary education enrolment ratio (of the population aged over 15). All the variables are expressed in percentages, which allows for convenient interpretation of the coefficients estimated. In order to account for unobserved business cycle effects, all estimations include a set of time dummies d_T .

Our crucial explanatory variable of interest, $(trade_p/VA)_{it}$, is a measure of the trade penetration ratio (the value of trade flows reported by country i and divided by the reporting country's added value, expressed as a percentage), with p denoting the partner's group. We take exports and imports into account separately, and also check whether the choice of trade partners is important for productivity changes, and additionally account for the differences between overall trade and trade in intermediate goods. Consequently,

$$(trade_p/VA)_{it} = \frac{\sum_{k=1}^K trade_p_{ikt}}{VA_{it}} \quad \forall p = \{WLD, EU25, EU15, NMS10\}; \forall k \neq i, \quad (8)$$

where i denotes the reporting country, k is the partner country belonging to the partners' group $p = \{WLD, EU25, EU15, NMS10\}$ and $trade = \{exp_total, exp_interm, imp_total, imp_interm\}$, where exp_total and imp_total denote flows of all types of goods, while exp_interm and imp_interm refer to flows of intermediate goods only. For example, $(exp_total_NMS10/VA)_i$ denotes the ratio of total exports to NMS-10 countries reported by country i to the added value of country i , while $(imp_interm_EU15/VA)_i$ is the ratio of intermediate good imports from the EU-15 countries reported by country i to the added value of country i .

As for the estimation method, the formulation adopted requires the use of panel data techniques. The use of standard alternative techniques to OLS (fixed effects or random effects) seems to be inappropriate due to potential endogeneity problems and a possible two-way relationship between trade and productivity: productivity may be enhanced by trade spillovers but greater trade openness can also be the result of higher productivity (selection) and thus greater competitiveness in international

²⁵ We have also tried including as control variable the level of RD (expressed as a share of R&D spending over GDP and as the number of researchers in R&D). These variables were not significant and had no impact on the other results.

markets. Consequently, we cannot treat variables linked to trade as strictly exogenous and in order to obtain consistent parameter estimates of β_4 , the use of instrumental variable (IV) techniques is required. We base the choice between IV fixed and random effects models on the Hausman test, finally relying on IV RE estimates obtained with Balestra and Varadharajan-Krishnakumar (1987)'s generalised two-stage least squares method (G2SLS) with trade variables instrumented by their lags²⁶. In the robustness checks, an alternative method of estimation is also considered. The results of the benchmark models are reported in Tables 4-7. In the description we focus on the role played by trade.²⁷

In all specifications, independently of whether we take into account exports or imports of all goods (Table 4 and Table 5) or of intermediate goods only (Table 6 and Table 7), the degree of trade penetration (openness) turns out to be positively and statistically significantly linked to intra-industry productivity growth in our sample of European countries. The coefficients associated with openness measures remain fairly stable regardless of which other control variables are included. However, our crucial findings concern the specific role of trade in productivity growth when we account for the heterogeneity of trade partners and alternative typologies of trade flows.

Looking at the ratio of exports (all products) to VA – Table 4 – it turns out that the greatest stimulus is given by trade with New Member States (exp_total_NMS10/VA : columns 13-16). Greater export penetration concerning all trade partners (exp_total_WLD/VA : columns 1-4) and partners from the EU-25 and the EU-15 (exp_total_EU25/VA : columns 5-8; exp_total_EU15/VA : columns 9-12) is also a positive, but weaker, determinant of intra-industry productivity growth. A rise in the ratio of exports to the NMS-10 to VA of the reporting country by 1 percentage point is associated with an

²⁶ The issue of a trade-productivity two-way relationship can also be addressed by the use of a gravity-based instrument for trade. This draws on bilateral trade data with country-specific characteristics employed in the gravity equation. The predicted values of trade are then summed up across partner countries to obtain a 'natural openness'. See Frankel and Romer (1999) and the application of their methodology in Alcalá and Ciccone (2004) or, at the sector level, in di Giovanni and Levchenko (2009) and Parteka and Wolszczak-Derlacz (2013), as well as the discussion of alternative estimators to be used in the gravity equation in Santos Silva and Tenreyro (2006).

²⁷ As far as additional variables are concerned, the coefficient associated with the distance from the technological frontier (*TechDist*) is in most cases negative (as expected), and almost always significant. *RDgr* turns out to be a robust and positive factor in promoting intra-industry labour productivity growth (however, the impact is not very strong, as the growth rate for R&D spending 1 percentage point higher is associated with approximately a 0.1 percentage point rise in the growth rate of intra-industry productivity). *HCgr* is not significant, but its inclusion in the model does not change the crucial results concerning the impact of trade on productivity growth.

approximately 0.34 percentage point rise in the intra-industry productivity growth rate (the effect is four to five times stronger than in the case of alternative groups of partners). The impact of imports from the NMS-10 (Table 5) is only slightly weaker but the same pattern is confirmed: openness with respect to imports from the NMS-10 exerts a stronger influence on intra-industry productivity growth than when we consider imports from the EU-15, the EU-25 or WLD.²⁸

Another important conclusion can be drawn when we focus on trade in intermediate goods. The results reported in Table 6 and Table 7 confirm the stimulating effects of more intense trade in intermediates on intra-industry productivity gains, and in general the effect is stronger than in the case of exports/imports of all goods. Again, however, the exchange of non-final goods and components with New Member States exerts a particularly strong effect on productivity growth in European countries. Moreover, the impact of trade in intermediates on productivity growth is stronger than the influence of trade in all goods: as reported in Table 6 (columns 13-16), a rise in the ratio of intermediate good exports to the NMS-10 to the VA of the exporting country by 1 percentage point is associated with as much as 0.6 percentage point higher rates of intra-industry productivity growth. Similarly, a rise in the ratio of intermediate good imports from the NMS-10 to the VA of the importing country by 1 percentage point is associated with rates of intra-industry productivity growth approximately 0.7-0.8 percentage points higher. The relationship of imports of intermediates to VA can be treated as a proxy for outsourcing intensity (Molnar et al., 2007) and thus we can confirm that outsourcing practises in the enlarged Europe have considerable productivity effects; in particular, a greater exchange of intermediates with New Member States contributed significantly to productivity growth in EU countries.

²⁸ Of course, this pattern can reflect the fact that in the period analysed trade penetration ratios concerning trade with the NMS-10 were generally much lower than in the case of trade with the EU-15, the EU-25 or WLD (Figure 1 and Figure 2). Thus rises in relatively low trade intensity with the NMS-10 were stronger in terms of their relative impact on productivity growth, but not necessarily in absolute terms.

3.3 Robustness checks²⁹

In order to check the robustness of our results (pointing towards a general stimulating influence of trade on productivity growth, with a stronger effect of trade with the NMS-10 and a greater influence of intermediate good trade than of that in all goods) we perform a set of additional estimations. First of all, we use total productivity growth (and not its intra-industry component) as an alternative left-hand side variable. Next, we check the robustness of the results with respect to the estimation method. We adopt (as alternative to G2SLS) Baltagi's (1981) EC2SLS random-effects IV estimator, which can be treated as a weighted average of the "within" and "between" estimators. We also check whether a change in the measure of the technological frontier is important for the results obtained: we use a measure based on the distance from the relative productivity of the whole sample of countries (thus expressed as VA/hour worked with the EU25 level being the benchmark, and not the EU15 as before). Then, given the insignificant result concerning human capital, we exclude it from the model. None of these changes significantly alter the results concerning the impact of trade on productivity.

Given the many ways of measuring trade openness, we try substituting our measures (Eq.8) with alternative ones, adopting the ratio of imports relative to the sum of imports net of exports plus output (as used by Chen et al., 2009):

$$(openness - p)_{iT} = \frac{\sum_{k=1}^K imports_{ikT} - p_{ikT}}{\sum_{k=1}^K (imports_{ikT} - exports_{ikT}) + output_{iT}}, \quad (9)$$

$$\forall p = \{WLD, EU25, EU15, NMS10\}; \forall k \neq i$$

where i denotes the reporting country, T the time period, and k is the partner country belonging to the partners' group $p = \{WLD, EU25, EU15, NMS10\}$. The degree of openness measured in this way is smaller than that when using the ratio of imports to added value, but the results of the estimations remain very stable.

²⁹ The results referred to in this section are reported in the Appendix. They contain the results without $HCgr$ variable which resulted to be insignificant and thus has been eliminated from the robustness models.

Finally, given that most of the trade with the NMS-10 is done with the five biggest countries from that group (Poland, Hungary, Slovenia, Slovakia and the Czech Republic), we check the robustness of our findings by including measures of trade penetration based on values of trade with this NMS-5 in the regressions. The results are very similar to those obtained with penetration ratios based on exports or imports to/from the NMS-10; again, the coefficients associated with exp_total_NMS5/VA , imp_total_NMS5/VA , exp_interm_NMS5/VA and imp_interm_NMS5/VA are positive, significant, robust to the inclusion of other control variables and higher than those obtained with trade penetration ratios referring to trade with the world, the EU25 or the EU15. The only difference is that the impact of exports (of all goods and intermediate goods only) to the NMS-5 is slightly weaker than exports to the NMS-10, while the effect of imports from the NMS-5 is a little stronger than imports from the NMS-10.

Table 4. Estimation results: intra-industry productivity growth versus *export* openness (reporters: EU25 countries, 1995-2007)

	Dep.var.: Intra-industry productivity growth (Pg^{Intra})															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
$TechDist_{t-1}$	-0.036*** [-3.360]	-0.037*** [-3.610]	-0.033*** [-3.338]	-0.035*** [-3.592]	-0.033*** [-3.103]	-0.035*** [-3.375]	-0.031*** [-3.108]	-0.033*** [-3.379]	-0.038*** [-3.449]	-0.039*** [-3.687]	-0.035*** [-3.438]	-0.037*** [-3.675]	-0.016 [-1.502]	-0.018* [-1.702]	-0.015 [-1.519]	-0.017* [-1.712]
$RDgr$	0.091** [2.354]		0.091** [2.374]		0.092** [2.379]		0.093** [2.403]		0.095** [2.427]		0.095** [2.446]		0.076** [2.017]		0.076** [2.014]	
$HCgr$	-0.039 [-0.754]	-0.041 [-0.796]			-0.032 [-0.607]	-0.035 [-0.667]			-0.038 [-0.740]	-0.042 [-0.798]			-0.013 [-0.248]	-0.015 [-0.285]		
exp_total_WLD / VA	0.076*** [3.584]	0.068*** [3.307]	0.075*** [3.624]	0.068*** [3.352]												
exp_total_EU25 / VA					0.093*** [3.472]	0.082*** [3.154]	0.093*** [3.546]	0.083*** [3.234]								
exp_total_EU15 / VA									0.105*** [3.229]	0.088*** [2.829]	0.103*** [3.265]	0.088*** [2.874]				
exp_total_NMS10 / VA													0.346*** [3.496]	0.338*** [3.411]	0.349*** [3.508]	0.342*** [3.429]
Time dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Number of obs.	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285
Number of groups#	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
chi2	50.5	45	50.19	44.64	49.53	43.82	49.41	43.62	47.36	41.34	46.98	40.94	53.48	49	52.31	47.82
p	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R2	0.34	0.33	0.35	0.34	0.32	0.31	0.33	0.32	0.25	0.25	0.26	0.26	0.58	0.55	0.58	0.56

Notes: exp_total_WLD / VA : ratio of exports to the World to value added of reporting country, exp_total_EU25 / VA : ratio of exports to EU25 to value added of reporting country, exp_total_EU15 / VA : ratio of exports to EU15 to value added of reporting country, exp_total_NMS10 / VA : ratio of exports to NMS10 to value added of reporting country; all trade penetration rates in %. $TechDist$: relative productivity – VA/hours worked (in %, EU15=100%). $RDgr$: growth of R&D expenditure (with respect to GDP), in %. $HCgr$: growth of human capital (tertiary education enrolment ratio), in %. Constant included – not reported. Results of random effects IV estimations (G2SLS), choice of RE versus FE based on Hausman test. Trade penetration rates instrumented with lags. Time dummies included. t-statistics in square brackets, * p<0.10, ** p<0.05, *** p<0.01. # BEL and LUX are treated jointly as BLX.

Source: own calculations

Table 5. Estimation results: intra-industry productivity growth versus *import* openness (reporter: EU25 countries, 1995-2007)

	Dep.var.: Intra-industry productivity growth (Pg^{Intra})															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
$TechDist_{t-1}$	-0.023**	-0.025**	-0.020*	-0.022**	-0.027**	-0.028**	-0.024**	-0.025**	-0.032***	-0.033***	-0.029***	-0.030***	-0.018*	-0.021*	-0.015	-0.018*
	[-1.977]	[-2.225]	[-1.849]	[-2.096]	[-2.276]	[-2.461]	[-2.141]	[-2.330]	[-2.811]	[-2.997]	[-2.686]	[-2.878]	[-1.661]	[-1.910]	[-1.571]	[-1.825]
$RDgr$	0.078**		0.078**		0.068*		0.069*		0.068*		0.069*		0.078**		0.078**	
	[2.012]		[2.026]		[1.757]		[1.788]		[1.737]		[1.771]		[2.027]		[2.053]	
$HCgr$	-0.049	-0.05			-0.052	-0.053			-0.057	-0.058			-0.027	-0.03		
	[-0.935]	[-0.962]			[-0.990]	[-1.012]			[-1.080]	[-1.099]			[-0.515]	[-0.570]		
imp_total_WLD / VA	0.072***	0.068***	0.071***	0.066***												
	[2.983]	[2.847]	[2.990]	[2.863]												
imp_total_EU25 / VA					0.087**	0.084**	0.085**	0.082**								
					[2.522]	[2.465]	[2.528]	[2.472]								
imp_total_EU15 / VA									0.084**	0.080**	0.079**	0.076**				
									[2.193]	[2.131]	[2.131]	[2.072]				
imp_total_NMS10 / VA													0.289***	0.271***	0.300***	0.281***
													[2.859]	[2.646]	[3.049]	[2.817]
Time dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Number of obs.	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285
Number of groups#	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
chi2	45.78	41.62	45.31	41.14	42.76	39.17	42.25	38.6	40.93	37.35	40.09	36.48	48.94	43.62	49.93	44.23
p	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R2	0.33	0.33	0.34	0.34	0.29	0.28	0.3	0.29	0.22	0.22	0.24	0.23	0.59	0.55	0.6	0.56

Notes: imp_total_WLD / VA : ratio of imports from the World to value added of reporting country, imp_total_EU25 / VA : ratio of imports from the EU25 to value added of reporting country, imp_total_EU15 / VA : ratio of imports from the EU15 to value added of reporting country, imp_total_NMS10 / VA : ratio of imports from the NMS10 to value added of reporting country; all trade penetration rates in %. $TechDist$: relative productivity – VA/hours worked (in %, EU15=100%). $RDgr$: growth of R&D expenditure (with respect to GDP), in %. $HCgr$: growth of human capital (tertiary education enrolment ratio), in %. Constant included – not reported. Results of random effects IV estimations (G2SLS), choice of RE versus FE based on Hausman test. Trade penetration rates instrumented with lags. Time dummies included. t-statistics in square brackets, * p<0.10, ** p<0.05, *** p<0.01. # BEL and LUX are treated jointly as BLX.

Source: own calculations

Table 6. Estimation results: intra-industry productivity growth versus *intermediate good export openness* (reporter: EU25 countries, 1995-2007)

	Dep.var.: Intra-industry productivity growth (Pg^{Intra})															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
$TechDist_{t-1}$	-0.036*** [-3.295]	-0.038*** [-3.555]	-0.033*** [-3.272]	-0.035*** [-3.530]	-0.032*** [-2.862]	-0.034*** [-3.183]	-0.030*** [-2.891]	-0.032*** [-3.203]	-0.035*** [-3.201]	-0.037*** [-3.471]	-0.033*** [-3.222]	-0.035*** [-3.484]	-0.024** [-2.148]	-0.027** [-2.402]	-0.022** [-2.093]	-0.024** [-2.344]
$RDgr$	0.094** [2.403]		0.095** [2.424]		0.095** [2.406]		0.095** [2.427]		0.092** [2.338]		0.093** [2.357]		0.081** [2.103]		0.082** [2.126]	
$HCgr$	-0.04 [-0.759]	-0.043 [-0.827]			-0.028 [-0.540]	-0.034 [-0.640]			-0.032 [-0.614]	-0.037 [-0.706]			-0.03 [-0.568]	-0.033 [-0.631]		
exp_interm_WLD / VA	0.123*** [2.905]	0.101** [2.500]	0.121*** [2.940]	0.101** [2.539]												
exp_interm_EU25 / VA					0.179*** [3.027]	0.148*** [2.603]	0.178*** [3.109]	0.149*** [2.693]								
exp_interm_EU15 / VA									0.189*** [2.785]	0.155** [2.372]	0.187*** [2.847]	0.155** [2.443]				
exp_interm_NMS10 / VA													0.594** [2.433]	0.547** [2.251]	0.610** [2.528]	0.563** [2.352]
Time dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Number of obs.	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285
Number of groups#	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
chi2	45.26	39.49	44.86	39.04	45.86	39.96	45.78	39.8	44.13	38.55	43.9	38.26	44.24	39.6	43.91	39.22
p	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R2	0.27	0.27	0.28	0.28	0.27	0.27	0.27	0.27	0.23	0.23	0.23	0.24	0.45	0.42	0.47	0.44

Notes: exp_interm_WLD / VA : ratio of exports of intermediate goods to the World to value added of reporting country, exp_interm_EU25 / VA : ratio of exports of intermediate goods to the EU25 to value added of reporting country, exp_interm_EU15 / VA : ratio of exports of intermediate goods to the EU15 to value added of reporting country, exp_interm_NMS10 / VA : ratio of exports of intermediate goods to the NMS10 to value added of reporting country; all trade penetration rates in %. $TechDist$: relative productivity – VA/hours worked (in %, EU15=100%). $RDgr$: growth of R&D expenditure (with respect to GDP), in %. $HCgr$: growth of human capital (tertiary education enrolment ratio), in %. Constant included – not reported. Results of random effects IV estimations (G2SLS), choice of RE versus FE based on Hausman test. Trade penetration rates instrumented with lags. Time dummies included. t-statistics in square brackets, * p<0.10, ** p<0.05, *** p<0.01. # BEL and LUX are treated jointly as BLX.

Source: own calculations

Table 7. Estimation results: intra-industry productivity growth versus *intermediate goods' import* openness (reporter: EU25 countries, 1995-2007)

	Dep.var.: Intra-industry productivity growth (Pg^{Intra})															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
$TechDist_{t-1}$	-0.025**	-0.028**	-0.022**	-0.025**	-0.024**	-0.027**	-0.022*	-0.024**	-0.029**	-0.031***	-0.026**	-0.028***	-0.018*	-0.022**	-0.016	-0.020*
	[-2.081]	[-2.426]	[-2.013]	[-2.356]	[-2.006]	[-2.298]	[-1.933]	[-2.226]	[-2.476]	[-2.742]	[-2.409]	[-2.677]	[-1.665]	[-1.972]	[-1.612]	[-1.908]
$RDgr$	0.088**		0.089**		0.081**		0.081**		0.078**		0.079**		0.083**		0.084**	
	[2.257]		[2.272]		[2.063]		[2.085]		[1.993]		[2.012]		[2.168]		[2.195]	
$HCgr$	-0.039	-0.043			-0.039	-0.042			-0.044	-0.047			-0.024	-0.029		
	[-0.748]	[-0.809]			[-0.745]	[-0.794]			[-0.842]	[-0.881]			[-0.464]	[-0.558]		
imp_interm_WLD / VA	0.140***	0.121**	0.138***	0.120***												
	[2.880]	[2.558]	[2.917]	[2.604]												
imp_interm_EU25 / VA					0.164**	0.145**	0.163**	0.145**								
					[2.362]	[2.149]	[2.427]	[2.220]								
imp_interm_EU15 / VA									0.150**	0.133*	0.148**	0.132*				
									[2.017]	[1.829]	[2.042]	[1.863]				
imp_interm_NMS10 / VA													0.760***	0.685**	0.779***	0.708***
													[2.864]	[2.528]	[3.005]	[2.669]
Time dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Number of obs.	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285
Number of groups#	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
chi2	44.8	39.59	44.46	39.22	41.86	37.57	41.69	37.34	40.2	36.18	39.82	35.77	48.18	41.94	48.53	42.06
p	0.0000	0.0000	0.0000	0.0000	0.0000	0.0010	0.0000	0.0000	0.0000	0.0010	0.0000	0.0010	0.0000	0.0000	0.0000	0.0000
R2	0.26	0.26	0.27	0.27	0.27	0.27	0.28	0.28	0.24	0.24	0.24	0.25	0.54	0.49	0.55	0.5

Notes: imp_interm_WLD / VA : ratio of imports of intermediate goods from the World to value added of reporting country, imp_interm_EU25 / VA : ratio of imports of intermediate goods from the EU25 to value added of reporting country, imp_interm_EU15 / VA : ratio of imports of intermediate goods from the EU15 to value added of reporting country, imp_interm_NMS10 / VA : ratio of imports of intermediate goods from the NMS10 to value added of reporting country; all trade penetration rates in %. $TechDist$: relative productivity – VA/hours worked (in %, EU15=100%). $RDgr$: growth of R&D expenditure (with respect to GDP), in %. $HCgr$: growth of human capital (tertiary education enrolment ratio), in %. Constant included – not reported. Results of random effects IV estimations (G2SLS), choice of RE versus FE based on Hausman test. Trade penetration rates instrumented with lags. Time dummies included. t-statistics in square brackets, * p<0.10, ** p<0.05, *** p<0.01. # BEL and LUX are treated jointly as BLX.

Source: own calculations

4. Summary of findings and conclusions

The aim of this paper has been to empirically assess the link between the intra-industry component of productivity growth and trade patterns in a sample of 25 European Countries (the EU-15 and the ten economies that joined the EU in 2004) in the years following trade liberalisation between Western and Eastern European countries. Due to the availability of the disaggregated data needed to isolate the intra-industry component, we have focussed on the period 1995-2007. The analysis has aimed to fill a gap in productivity-trade research concerning both ‘old’ and ‘new’ EU member states, analysed in a framework of underlying intra-industry developments.

Recent theoretical contributions of ‘new-new trade’ models suggest that trade affects productivity mainly by stimulating firms’ performance due to mechanisms linked to stronger competition and self-selection, thus raising the productivity levels of separate industries. Consequently, even though we have estimated the productivity-trade nexus at the level of countries, we first isolated the intra-industry component of productivity growth by drawing on disaggregated industrial statistics. Our analysis should be understood as complementary to traditional industry-level studies on the impact of trade on productivity. The results of shift-share decomposition of the growth in added value per hours worked confirm that in our broad sample of European countries, intra-industry mechanisms were far more important in provoking productivity gains than labour shifts across industries.

In the next step, we estimated econometrically, by means of an instrumental variables method, the relationship between different trade penetration ratios and the intra-industry component of productivity growth. We accounted for heterogeneous effects of exports and imports, also checking whether the typology of goods traded (exchange of all goods versus intermediate goods) and different partners’ groups matter for productivity growth. By doing so we tested not only the importance of trade as such, but also whether the choice of trade partners is important and if exchange of intermediate goods affects productivity in a different manner to total trade.

Our findings have important policy implications. First of all, we confirm that trade can stimulate intra-industry productivity gains. Exports and imports alike positively influence productivity

growth while intermediate good exchange exerts an even stronger (approximately twice as intense) influence on productivity than trade in all goods. In other words, more intensity of trade in intermediate goods can be linked with rises in intra-industry efficiency. This proves a stimulating, in terms of growth, influence of outsourcing practises across the enlarged European Union.

Moreover, trade integration with less developed countries (in our case, the NMS) seems to have had a particularly strong and positive effect on the pace of productivity growth in reporting countries: the effect is four to five times stronger than in the case of trade with alternative groups of partners. This is an important result, and contrary to the common view that only trade with more advanced economies stimulates domestic productivity gains.

Our results remain robust to changes in the estimation method, the way of measuring openness, a broader definition of the technological frontier and restricting the NMS group to five CEECs only.

The analysis presented in this paper could be further enriched through the use of data from the recently released WIOD (World Input-Output Database, April 2012; for details on contents, sources and methods see Timmer et al., 2012a), which is an update and extension of EUKLEMS. This would give the opportunity to extend the country and time dimension of the analysis (WIOD covers 27 EU countries and 13 other major countries in the world for the period from 1995 to 2009). Moreover, it would now be possible to deepen the examination by employing WIOD's Socio-Economic Accounts (containing updated data on labour, capital and remuneration for a much broader set of countries than was previously available), as well as using WIOD's combination of national input-output tables, bilateral international trade statistics and data on production factor requirements to construct more precise measures of outsourcing and slice up global value chains (see Timmer et al., 2012b).

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APPENDIX

Table A1. List of sectors used in the productivity analysis

	Description (code)	Class
1	Food, beverages and tobacco (15t16)	Manuf
2	Textiles, leather and footwear (17t19)	Manuf
3	Wood and products of wood and cork (20)	Manuf
4	Pulp, paper, paper products, printing and publishing (21t22)	Manuf
5	Coke, refined petroleum and nuclear fuel (23)	Manuf
6	Chemicals and chemical products (24)	Manuf
7	Rubber and plastics (25)	Manuf
8	Other non-metallic mineral products (26)	Manuf
9	Basic metals and fabricated metal products (27t28)	Manuf
10	Machinery, n.e.c. (29)	Manuf
11	Electrical and optical equipment (30t33)	Manuf
12	Transport equipment (34t35)	Manuf
13	Manufacturing n.e.c., recycling (36t37)	Manuf
14	Sale, maintenance and trade of vehicles (50)	
15	Wholesale and commission trade except of motor vehicles and motorcycles (51)	
16	Retail trade except of motor vehicles and motorcycles (52)	
17	Transport and storage (60t63)	
18	Post and telecommunications (64)	
19	Real estate activities (70)	
20	Renting of m&eq and other business activities (71t74)	
21	Agriculture, hunting, forestry and fishing (AtB)	
22	Mining and quarrying (C)	
23	Electricity, gas and water supply (E)	
24	Construction (F)	
25	Hotels and restaurants (H)	
26	Financial intermediation (J)	
27	Public admin and defence; compulsory social security (L)	
28	Education (M)	
29	Health and social work (N)	
30	Other community, social and personal services (O)	

Note: Manuf – manufacturing; EU KLEMS codes in parenthesis

Source: own elaboration based on EUKLEMS

ROBUSTNESS CHECKS
(Changed details of estimation - in bold)

Robustness A. Total productivity growth instead of Intra-industry productivity growth

Table A1. Estimation results: total productivity growth versus export openness

	Dep.var.: Total productivity growth															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<i>exp_total_WLD / VA</i>	0.083*** [3.618]	0.065*** [3.454]	0.072*** [3.750]	0.090*** [3.943]												
<i>exp_total_EU25 / VA</i>					0.106*** [3.681]	0.079*** [3.323]	0.089*** [3.671]	0.115*** [4.028]								
<i>exp_total_EU15 / VA</i>									0.109*** [3.159]	0.083*** [2.920]	0.099*** [3.349]	0.126*** [3.615]				
<i>exp_total_NMS10 / VA</i>													0.426*** [5.288]	0.353*** [3.934]	0.362*** [4.063]	0.422*** [5.464]
<i>TechDist_{t-1}</i>		-0.031*** [-3.482]	-0.029*** [-3.148]			-0.029*** [-3.231]	-0.027*** [-2.877]			-0.032*** [-3.491]	-0.030*** [-3.161]			-0.014 [-1.551]	-0.012 [-1.302]	
<i>RDgr</i>			0.098** [2.565]	0.108*** [2.795]			0.099*** [2.603]	0.109*** [2.830]			0.101*** [2.633]	0.113*** [2.888]			0.084** [2.274]	0.089** [2.417]
Number of obs.	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285
Number of groups	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
chi2	33.29	44.62	50.96	41.3	33.77	43.32	50.01	42.01	30.08	98.8	46.83	38.68	47.73	52.93	58.96	56.15
p	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: *exp_total_WLD / VA*: ratio of exports to the World to value added of reporting country, *exp_total_EU25 / VA*: ratio of exports to EU25 to value added of reporting country, *exp_total_EU15 / VA*: ratio of exports to EU15 to value added of reporting country, *exp_total_NMS10 / VA*: ratio of exports to NMS10 to value added of reporting country; all trade penetration rates in %. *TechDist_{t-1}*: relative productivity – VA/hours worked (in %, EU15=100%). *RDgr*: growth of R&D expenditure (with respect to GDP), in %. Constant included – not reported. Results of random effects IV estimations (G2SLS), choice of RE versus FE based on Hausman test. Trade penetration rates instrumented with their lags. Time dummies included. t-statistics in squared parenthesis, * p<0.10, ** p<0.05, *** p<0.01.

Source: own calculations

Table A2. Estimation results: total productivity growth versus import openness

	Dep.var.: Total productivity growth															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<i>imp_total_WLD / VA</i>	0.093*** [4.348]	0.070*** [3.337]	0.074*** [3.465]	0.095*** [4.425]												
<i>imp_total_EU25 / VA</i>					0.128*** [4.038]	0.090*** [3.015]	0.094*** [3.090]	0.127*** [4.030]								
<i>imp_total_EU15 / VA</i>									0.136*** [3.514]	0.085** [2.524]	0.088*** [2.589]	0.135*** [3.498]				
<i>imp_total_NMS10 / VA</i>													0.387*** [5.139]	0.305*** [3.367]	0.325*** [3.676]	0.394*** [5.525]
<i>TechDist_{t-1}</i>		-0.018* [-1.855]	-0.015 [-1.538]			-0.020** [-2.039]	-0.018* [-1.786]			-0.025*** [-2.607]	-0.023** [-2.356]			-0.015 [-1.622]	-0.012 [-1.320]	
<i>RDgr</i>			0.084** [2.214]	0.091** [2.374]			0.076** [1.996]	0.078** [2.030]			0.075* [1.959]	0.078** [2.002]			0.087** [2.330]	0.094** [2.532]
Number of obs.	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285
Number of groups	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
chi2	38.75	110.7	48.93	45.08	81.66	105.12	45.87	41.48	71.16	37.8	42.16	37.33	45.53	49.44	57.39	56.46
p	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: *imp_total_WLD / VA*: ratio of imports from the World to value added of reporting country, *imp_total_EU25 VA*: ratio of imports from EU25 to value added of reporting country, *imp_total_EU15/VA*: ratio of imports from EU15 to value added of reporting country, *imp_total_NMS10/VA*: ratio of imports from NMS10 to value added of reporting country; all trade penetration rates in %. *TechDist_{t-1}*: relative productivity – VA/hours worked (in %, EU15=100%). *RDgr*: growth of R&D expenditure (with respect to GDP), in %. Constant included – not reported. Results of random effects IV estimations (G2SLS), choice of RE versus FE based on Hausman test. Trade penetration rates instrumented with their lags. Time dummies included. t-statistics in squared parenthesis, * p<0.10, ** p<0.05, *** p<0.01.

Source: own calculations

Table A3. Estimation results: total productivity growth versus intermediate goods' export openness

	Dep.var.: Total productivity growth															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<i>exp_inter_WLD / VA</i>	0.126*** [2.830]	0.093** [2.542]	0.113*** [2.972]	0.147*** [3.275]												
<i>exp_inter_EU25 / VA</i>					0.197*** [3.222]	0.136*** [2.687]	0.165*** [3.135]	0.225*** [3.670]								
<i>exp_inter_EU15 / VA</i>									0.197*** [2.773]	0.137** [2.347]	0.168*** [2.773]	0.230*** [3.209]				
<i>exp_inter_NMS10 / VA</i>													0.789*** [3.631]	0.575*** [2.661]	0.627*** [2.893]	0.808*** [3.935]
<i>TechDist_{t-1}</i>		-0.031*** [-3.393]	-0.029*** [-3.052]			-0.028*** [-3.070]	-0.025*** [-2.671]			-0.031*** [-3.347]	-0.028*** [-3.002]			-0.021** [-2.175]	-0.018* [-1.855]	
<i>RDgr</i>			0.101*** [2.600]	0.112*** [2.854]			0.101*** [2.601]	0.113*** [2.877]			0.097** [2.508]	0.110*** [2.787]			0.090** [2.381]	0.098*** [2.579]
Number of obs.	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285
Number of groups	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
chi2	65.39	98.46	44.69	36.17	30.25	38.91	45.62	38.79	27.43	36.92	43.11	35.39	33.04	40.75	46.76	41.18
p	0.000	0.000	0.000	0.001	0.003	0.000	0.000	0.000	0.007	0.000	0.000	0.001	0.001	0.000	0.000	0.000

Notes: *exp_inter_WLD / VA*: ratio of exports of intermediate goods to the World to value added of reporting country, *exp_inter_EU25 / VA*: ratio of exports of intermediate goods to EU25 to value added of reporting country, *exp_inter_EU15 / VA*: ratio of exports of intermediate goods to EU15 to value added of reporting country, *exp_inter_NMS10 / VA*: ratio of exports of intermediate goods to NMS10 to value added of reporting country; all trade penetration rates in %. *TechDist_{t-1}*: relative productivity – VA/hours worked (in %, EU15=100%). *RDgr*: growth of R&D expenditure (with respect to GDP), in %. Constant included – not reported. Results of random effects IV estimations (G2SLS), choice of RE versus FE based on Hausman test. Trade penetration rates instrumented with their lags. Time dummies included. t-statistics in squared parenthesis, * p<0.10, ** p<0.05, *** p<0.01.

Source: own calculations

Table A4. Estimation results: total productivity growth versus intermediate goods' import openness

	Dep.var.: Total productivity growth															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<i>imp_interm_WLD / VA</i>	0.178*** [3.930]	0.121*** [2.882]	0.139*** [3.218]	0.191*** [4.212]												
<i>imp_interm_EU25 / VA</i>					0.232*** [3.807]	0.154*** [2.599]	0.171*** [2.829]	0.239*** [3.946]								
<i>imp_interm_EU15 / VA</i>									0.238*** [3.328]	0.137** [2.140]	0.152** [2.331]	0.245*** [3.446]				
<i>imp_interm_NMS10 / VA</i>													0.987*** [4.685]	0.776*** [3.260]	0.852*** [3.693]	1.018*** [5.303]
<i>TechDist_{t-1}</i>		-0.021** [-2.136]	-0.017* [-1.710]			-0.020** [-1.994]	-0.017 [-1.622]			-0.024** [-2.500]	-0.021** [-2.156]			-0.015* [-1.661]	-0.012 [-1.317]	
<i>RDgr</i>			0.095** [2.479]	0.105*** [2.726]			0.089** [2.306]	0.096** [2.475]			0.085** [2.210]	0.094** [2.413]			0.095** [2.527]	0.103*** [2.763]
Number of obs.	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285
Number of groups	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
chi2	35.36	40.18	46.32	43.24	34.02	39.04	44.3	40.59	72.92	36.6	41.39	36.67	41.55	46.75	55.94	54.22
p	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: *imp_interm_WLD / VA*: ratio of imports of intermediate goods from the World to value added of reporting country, *imp_interm_EU25 / VA*: ratio of imports of intermediate goods from EU25 to value added of reporting country, *imp_interm_EU15 / VA*: ratio of imports of intermediate goods from EU15 to value added of reporting country, *imp_interm_NMS10 / VA*: ratio of imports of intermediate goods from NMS10 to value added of reporting country; all trade penetration rates in %. *TechDist_{t-1}*: relative productivity – VA/hours worked (in %, EU15=100%). *RDgr*: growth of R&D expenditure (with respect to GDP), in %. Constant included – not reported. Results of random effects IV estimations (G2SLS), choice of RE versus FE based on Hausman test. Trade penetration rates instrumented with their lags. Time dummies included. t-statistics in squared parenthesis, * p<0.10, ** p<0.05, *** p<0.01.

Source: own calculations

Robustness B. Alternative method of estimation (EC2SLS random-effects IV estimator)

Table B1. Estimation results: total productivity growth versus export openness, EC2SLS

	Dep.var.: Intra-industry productivity growth															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<i>exp_total_WLD / VA</i>	0.076*** [3.259]	0.063*** [3.149]	0.069*** [3.380]	0.082*** [3.509]												
<i>exp_total_EU25 / VA</i>					0.095*** [3.244]	0.075*** [2.985]	0.084*** [3.252]	0.102*** [3.512]								
<i>exp_total_EU15 / VA</i>									0.093*** [2.647]	0.074** [2.458]	0.087*** [2.771]	0.106*** [2.983]				
<i>exp_total_NMS10 / VA</i>													0.426*** [5.097]	0.376*** [3.921]	0.384*** [4.033]	0.423*** [5.233]
<i>TechDist_{t-1}</i>		-0.028*** [-2.946]	-0.026*** [-2.662]			-0.026*** [-2.737]	-0.024** [-2.440]			-0.029*** [-2.959]	-0.027*** [-2.682]			-0.01 [-1.052]	-0.008 [-0.834]	
<i>RDgr</i>			0.092** [2.369]	0.100** [2.560]			0.093** [2.391]	0.101*** [2.580]			0.094** [2.386]	0.103*** [2.595]			0.080** [2.100]	0.083** [2.204]
Number of obs.	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285
Number of groups	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
chi2	30.12	38.33	43.55	36.52	30.05	37.1	42.51	36.58	26.43	33.61	38.89	32.98	45.06	47.36	52.46	51.91
p	0.003	0	0	0	0.003	0	0	0	0.009	0.001	0	0.002	0	0	0	0

Notes: *exp_total_WLD / VA*: ratio of exports to the World to value added of reporting country, *exp_total_EU25 / VA*: ratio of exports to EU25 to value added of reporting country, *exp_total_EU15 / VA*: ratio of exports to EU15 to value added of reporting country, *exp_total_NMS10 / VA*: ratio of exports to NMS10 to value added of reporting country; all trade penetration rates in %. *TechDist_{t-1}*: relative productivity – VA/hours worked (in %, EU15=100%). *RDgr*: growth of R&D expenditure (with respect to GDP), in %. Constant included – not reported. **Results of random effects IV estimations (EC2SLS).** Trade penetration rates instrumented with their lags. Time dummies included. t-statistics in squared parenthesis, * p<0.10, ** p<0.05, *** p<0.01.

Source: own calculations

Table B2. Estimation results: total productivity growth versus import openness, EC2SLS

	Dep.var.: Intra-industry productivity growth															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<i>imp_total_WLD / VA</i>	0.082*** [3.689]	0.061*** [2.731]	0.064*** [2.798]	0.083*** [3.695]												
<i>imp_total_EU25 / VA</i>					0.106*** [3.240]	0.073** [2.270]	0.075** [2.326]	0.105*** [3.214]								
<i>imp_total_EU15 / VA</i>									0.102** [2.571]	0.056 [1.590]	0.059 [1.641]	0.100** [2.537]				
<i>imp_total_NMS10 / VA</i>													0.393*** [4.962]	0.335*** [3.466]	0.355*** [3.746]	0.399*** [5.245]
<i>TechDist_{t-1}</i>		-0.017 [-1.611]	-0.015 [-1.362]			-0.019* [-1.835]	-0.017 [-1.623]			-0.024** [-2.363]	-0.023** [-2.149]			-0.01 [-1.063]	-0.007 [-0.785]	
<i>RDgr</i>			0.080** [2.050]	0.085** [2.189]			0.072* [1.847]	0.074* [1.888]			0.072* [1.837]	0.074* [1.887]			0.082** [2.161]	0.087** [2.292]
Number of obs.	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285
Number of groups	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
chi2	32.78	35.85	39.77	37.59	29.68	33.04	36.83	34.04	25.83	29.93	33.62	30.07	43.15	44.22	50.94	51.64
p	0.001	0.001	0	0	0.003	0.002	0.001	0.001	0.011	0.005	0.002	0.005	0	0	0	0

Notes: *imp_total_WLD / VA*: ratio of imports from the World to value added of reporting country, *imp_total_EU25 VA*: ratio of imports from EU25 to value added of reporting country, *imp_total_EU15/VA*: ratio of imports from EU15 to value added of reporting country, *imp_total_NMS10/VA*: ratio of imports from NMS10 to value added of reporting country; all trade penetration rates in %. *TechDist_{t-1}*: relative productivity – VA/hours worked (in %, EU15=100%). *RDgr*: growth of R&D expenditure (with respect to GDP), in %. Constant included – not reported. **Results of random effects IV estimations (EC2SLS)**. Trade penetration rates instrumented with their lags. Time dummies included. t-statistics in squared parenthesis, * p<0.10, ** p<0.05, *** p<0.01.

Source: own calculations

Table B3. Estimation results: total productivity growth versus intermediate goods' export openness, EC2SLS

	Dep.var.: Intra-industry productivity growth															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<i>exp_inter_WLD / VA</i>	0.112** [2.472]	0.085** [2.195]	0.101** [2.513]	0.129*** [2.806]												
<i>exp_inter_EU25 / VA</i>					0.165*** [2.679]	0.116** [2.164]	0.136** [2.457]	0.185*** [2.984]								
<i>exp_inter_EU15 / VA</i>									0.157** [2.194]	0.109* [1.779]	0.130** [2.054]	0.180** [2.487]				
<i>exp_inter_NMS10 / VA</i>													0.786*** [3.529]	0.615*** [2.677]	0.665*** [2.882]	0.807*** [3.797]
<i>TechDist_{t-1}</i>		-0.028*** [-2.865]	-0.026*** [-2.579]			-0.026*** [-2.616]	-0.023** [-2.297]			-0.028*** [-2.836]	-0.026** [-2.555]			-0.017* [-1.688]	-0.014 [-1.410]	
<i>RDgr</i>			0.093** [2.368]	0.103*** [2.589]			0.092** [2.335]	0.102*** [2.581]			0.089** [2.242]	0.099** [2.483]			0.086** [2.214]	0.091** [2.377]
Number of obs.	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285
Number of groups	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
chi2	25.44	32.46	37.62	31.86	26.49	32.37	37.37	32.88	24.02	30.62	35.25	29.97	31.65	36.37	41.55	38.54
p	0.013	0.002	0.001	0.003	0.009	0.002	0.001	0.002	0.02	0.004	0.001	0.005	0.002	0.001	0	0

Notes: *exp_inter_WLD / VA*: ratio of exports of intermediate goods to the World to value added of reporting country, *exp_inter_EU25 / VA*: ratio of exports of intermediate goods to EU25 to value added of reporting country, *exp_inter_EU15 / VA*: ratio of exports of intermediate goods to EU15 to value added of reporting country, *exp_inter_NMS10 / VA*: ratio of exports of intermediate goods to NMS10 to value added of reporting country; all trade penetration rates in %. *TechDist_{t-1}*: relative productivity – VA/hours worked (in %, EU15=100%). *RDgr*: growth of R&D expenditure (with respect to GDP), in %. Constant included – not reported. **Results of random effects IV estimations (EC2SLS).** Trade penetration rates instrumented with their lags. Time dummies included. t-statistics in squared parenthesis, * p<0.10, ** p<0.05, *** p<0.01.

Source: own calculations

Table B4. Estimation results: total productivity growth versus intermediate goods' import openness, EC2SLS

	Dep.var.: Intra-industry productivity growth															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<i>imp_interm_WLD / VA</i>	0.156*** [3.344]	0.106** [2.362]	0.119*** [2.585]	0.164*** [3.510]												
<i>imp_interm_EU25 / VA</i>					0.193*** [3.074]	0.121* [1.920]	0.134** [2.079]	0.198*** [3.149]								
<i>imp_interm_EU15 / VA</i>									0.186** [2.549]	0.093 [1.373]	0.103 [1.493]	0.190*** [2.602]				
<i>imp_interm_NMS10 / VA</i>													0.980*** [4.439]	0.826*** [3.232]	0.897*** [3.607]	1.011*** [4.924]
<i>TechDist_{t-1}</i>		-0.019* [-1.847]	-0.016 [-1.512]			-0.020* [-1.823]	-0.017 [-1.527]			-0.024** [-2.287]	-0.021** [-2.014]			-0.012 [-1.170]	-0.008 [-0.861]	
<i>RDgr</i>			0.088** [2.257]	0.097** [2.478]			0.082** [2.092]	0.088** [2.258]			0.079** [2.008]	0.087** [2.201]			0.089** [2.331]	0.095** [2.498]
Number of obs.	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285
Number of groups	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
chi2	30.48	33.32	38.05	36.34	28.41	31.63	35.81	33.52	25.42	29.69	33.53	30.23	38.66	41.18	48.66	48.55
p	0.002	0.002	0.001	0.001	0.005	0.003	0.001	0.001	0.013	0.005	0.002	0.004	0	0	0	0

Notes: *imp_interm_WLD / VA*: ratio of imports of intermediate goods from the World to value added of reporting country, *imp_interm_EU25 / VA*: ratio of imports of intermediate goods from EU25 to value added of reporting country, *imp_interm_EU15 / VA*: ratio of imports of intermediate goods from EU15 to value added of reporting country, *imp_interm_NMS10 / VA*: ratio of imports of intermediate goods from NMS10 to value added of reporting country; all trade penetration rates in %. *TechDist_{t-1}*: relative productivity – VA/hours worked (in %, EU15=100%). *RDgr*: growth of R&D expenditure (with respect to GDP), in %. Constant included – not reported. **Results of random effects IV estimations (EC2SLS)**. Trade penetration rates instrumented with their lags. Time dummies included. t-statistics in squared parenthesis, * p<0.10, ** p<0.05, *** p<0.01.

Source: own calculation

Robustness C. Alternative measure of technological distance (with respect to EU25 frontier)

Table C1. Estimation results: total productivity growth versus export openness

	Dep.var.: Intra-industry productivity growth															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<i>exp_total_WLD / VA</i>	0.082*** [3.474]	0.067*** [3.368]	0.075*** [3.641]	0.089*** [3.772]												
<i>exp_total_EU25 / VA</i>					0.104*** [3.544]	0.083*** [3.284]	0.093*** [3.600]	0.113*** [3.863]								
<i>exp_total_EU15 / VA</i>									0.105*** [2.993]	0.086*** [2.834]	0.102*** [3.229]	0.122*** [3.411]				
<i>exp_total_NMS10 / VA</i>													0.428*** [5.118]	0.379*** [3.959]	0.386*** [4.066]	0.424*** [5.243]
<i>TechDist_EU25</i>		-0.019*** [-2.893]	-0.017*** [-2.602]			-0.018*** [-2.665]	-0.016** [-2.357]			-0.020*** [-2.917]	-0.018*** [-2.631]			-0.007 [-1.020]	-0.005 [-0.803]	
<i>RDgr</i>			0.093** [2.405]	0.102*** [2.597]			0.095** [2.444]	0.103*** [2.632]			0.097** [2.470]	0.106*** [2.678]			0.080** [2.102]	0.083** [2.204]
Number of obs.	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285
Number of groups#	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
chi2	31.54	39.42	45.03	38.4	32.06	38.63	44.54	39.12	28.34	35.25	41.28	35.67	45.27	47.36	52.43	52.02
p	0.002	0	0	0	0.001	0	0	0	0.005	0.001	0	0.001	0	0	0	0

Notes: *exp_total_WLD / VA*: ratio of exports to the World to value added of reporting country, *exp_total_EU25 / VA*: ratio of exports to EU25 to value added of reporting country, *exp_total_EU15 / VA*: ratio of exports to EU15 to value added of reporting country, *exp_total_NMS10 / VA*: ratio of exports to NMS10 to value added of reporting country; all trade penetration rates in %. *TechDist_{t-1}*: relative productivity – VA/hours worked (in %, **EU25=100%**). *RDgr*: growth of R&D expenditure (with respect to GDP), in %. Constant included – not reported. Results of random effects IV estimations (G2SLS), choice of RE versus FE based on Hausman test. Trade penetration rates instrumented with their lags. Time dummies included. t-statistics in squared parenthesis, * p<0.10, ** p<0.05, *** p<0.01. # number of groups is equal to 24 because BEL and LUX are treated jointly as BLX.

Source: own calculations

Table C2. Estimation results: intra-industry productivity growth versus *import* openness

	Dep.var.: Intra-industry productivity growth															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<i>imp_total_WLD</i> / <i>VA</i>	0.090*** [4.029]	0.072*** [3.198]	0.077*** [3.331]	0.093*** [4.104]												
<i>imp_total_EU25</i> / <i>VA</i>					0.120*** [3.604]	0.089*** [2.757]	0.093*** [2.822]	0.119*** [3.592]								
<i>imp_total_EU15</i> / <i>VA</i>									0.123*** [3.063]	0.080** [2.232]	0.084** [2.291]	0.122*** [3.048]				
<i>imp_total_NMS10</i> / <i>VA</i>													0.389*** [4.912]	0.330*** [3.415]	0.348*** [3.683]	0.394*** [5.181]
<i>TechDist_t-1_EU25</i>		-0.01 [-1.353]	-0.008 [-1.071]			-0.011 [-1.580]	-0.01 [-1.363]			-0.015** [-2.119]	-0.014* [-1.901]			-0.007 [-1.081]	-0.005 [-0.810]	
<i>RDgr</i>			0.081** [2.077]	0.085** [2.194]			0.071* [1.831]	0.073* [1.859]			0.071* [1.808]	0.073* [1.846]			0.082** [2.156]	0.087** [2.292]
Number of obs.	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285
Number of groups#	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
chi2	35.35	38.21	42.6	40.69	32.11	35.08	38.95	36.53	28.53	31.96	35.73	32.81	42.66	43.55	50.15	50.99
p	0	0	0	0	0.001	0.001	0	0	0.005	0.002	0.001	0.002	0	0	0	0

Notes: *imp_total_WLD* / *VA*: ratio of imports from the World to value added of reporting country, *imp_total_EU25* / *VA*: ratio of imports from EU25 to value added of reporting country, *imp_total_EU15* / *VA*: ratio of imports from EU15 to value added of reporting country, *imp_total_NMS10* / *VA*: ratio of imports from NMS10 to value added of reporting country; all trade penetration rates in %. *TechDist_t-1*: relative productivity – VA/hours worked (in %, **EU25=100%**). *RDgr*: growth of R&D expenditure (with respect to GDP), in %. Constant included – not reported. Results of random effects IV estimations (G2SLS), choice of RE versus FE based on Hausman test. Trade penetration rates instrumented with their lags. Time dummies included. t-statistics in squared parenthesis, * p<0.10, ** p<0.05, *** p<0.01. # number of groups is equal to 24 because BEL and LUX are treated jointly as BLX.

Source: own calculations

Table C3. Estimation results: intra-industry productivity growth versus *intermediate goods'* export openness

	Dep.var.: Intra-industry productivity growth															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<i>exp_inter_WLD / VA</i>	0.127*** [2.775]	0.099** [2.544]	0.120*** [2.947]	0.147*** [3.189]												
<i>exp_inter_EU25 / VA</i>					0.201*** [3.208]	0.151*** [2.773]	0.181*** [3.197]	0.230*** [3.627]								
<i>exp_inter_EU15 / VA</i>									0.203*** [2.787]	0.152** [2.438]	0.184*** [2.845]	0.236*** [3.198]				
<i>exp_inter_NMS10 / VA</i>													0.806*** [3.600]	0.641*** [2.775]	0.690*** [2.981]	0.825*** [3.862]
<i>TechDist_t-1_EU25</i>		-0.019*** [-2.802]	-0.017** [-2.503]			-0.017** [-2.475]	-0.015** [-2.120]			-0.019*** [-2.749]	-0.017** [-2.445]			-0.011 [-1.608]	-0.009 [-1.329]	
<i>RDgr</i>			0.097** [2.455]	0.106*** [2.668]			0.098** [2.475]	0.107*** [2.704]			0.095** [2.385]	0.105*** [2.621]			0.086** [2.227]	0.092** [2.381]
Number of obs.	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285
Number of groups#	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
chi2	27	33.76	39.63	34.11	29.53	34.98	41.13	37.03	26.88	32.98	38.67	33.88	32.16	36.61	41.83	39.04
p	0.008	0.001	0	0.001	0.003	0.001	0	0	0.008	0.002	0	0.001	0.001	0	0	0

Notes: *exp_inter_WLD / VA*: ratio of exports of intermediate goods to the World to value added of reporting country, *exp_inter_EU25 / VA*: ratio of exports of intermediate goods to EU25 to value added of reporting country, *exp_inter_EU15 / VA*: ratio of exports of intermediate goods to EU15 to value added of reporting country, *exp_inter_NMS10 / VA*: ratio of exports of intermediate goods to NMS10 to value added of reporting country; all trade penetration rates in %. *TechDist_t-1*: relative productivity – VA/hours worked (in %, **EU25=100%**). *RDgr*: growth of R&D expenditure (with respect to GDP), in %. Constant included – not reported. Results of random effects IV estimations (G2SLS), choice of RE versus FE based on Hausman test. Trade penetration rates instrumented with their lags. Time dummies included. t-statistics in squared parenthesis, * p<0.10, ** p<0.05, *** p<0.01. # number of groups is equal to 24 because BEL and LUX are treated jointly as BLX.

Source: own calculations

Table C4. Estimation results: intra-industry productivity growth versus *intermediate goods' import* openness (reporter: EU25 countries, 1995-2007)

	Dep.var.: Intra-industry productivity growth															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<i>imp_interm_WLD / VA</i>	0.175*** [3.722]	0.130*** [2.865]	0.148*** [3.190]	0.188*** [3.987]												
<i>imp_interm_EU25 / VA</i>					0.225*** [3.527]	0.162** [2.533]	0.180*** [2.751]	0.232*** [3.655]								
<i>imp_interm_EU15 / VA</i>									0.228*** [3.076]	0.144** [2.078]	0.160** [2.264]	0.236*** [3.188]				
<i>imp_interm_NMS10 / VA</i>													0.977*** [4.424]	0.822*** [3.220]	0.894*** [3.595]	1.008*** [4.903]
<i>TechDist_t-1_EU25</i>		-0.011 [-1.591]	-0.009 [-1.206]			-0.011 [-1.469]	-0.009 [-1.138]			-0.014* [-1.945]	-0.012 [-1.639]			-0.008 [-1.156]	-0.006 [-0.847]	
<i>RDgr</i>			0.092** [2.344]	0.099** [2.532]			0.085** [2.155]	0.090** [2.282]			0.081** [2.064]	0.088** [2.228]			0.089** [2.330]	0.095** [2.497]
Number of obs.	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285
Number of groups#	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
chi2	33.09	35.53	41.09	39.82	31.31	33.89	38.54	36.84	28.27	31.62	35.88	33.47	38.52	40.8	48.28	48.34
p	0.001	0.001	0	0	0.002	0.001	0	0	0.005	0.003	0.001	0.001	0	0	0	0

Notes: *imp_interm_WLD / VA*: ratio of imports of intermediate goods from the World to value added of reporting country, *imp_interm_EU25 / VA*: ratio of imports of intermediate goods from EU25 to value added of reporting country, *imp_interm_EU15 / VA*: ratio of imports of intermediate goods from EU15 to value added of reporting country, *imp_interm_NMS10 / VA*: ratio of imports of intermediate goods from NMS10 to value added of reporting country; all trade penetration rates in %. *TechDist_t-1*: relative productivity – VA/hours worked (in %, **EU25=100%**). *RDgr*: growth of R&D expenditure (with respect to GDP), in %. Constant included – not reported. Results of random effects IV estimations (G2SLS), choice of RE versus FE based on Hausman test. Trade penetration rates instrumented with their lags. Time dummies included. t-statistics in squared parenthesis, * p<0.10, ** p<0.05, *** p<0.01. # number of groups is equal to 24 because BEL and LUX are treated jointly as BLX.

Source: own calculations

Robustness D. Alternative measure of trade openness (as in Chen et al., 2009)

Table D1. Estimation results: intra-industry productivity growth versus openness (all goods)

	Dep.var.: Intra-industry productivity growth															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<i>openness_WLD</i>	0.223*** [3.532]	0.170*** [2.860]	0.183*** [3.007]	0.233*** [3.662]												
<i>openness_EU25</i>					0.300*** [3.357]	0.217*** [2.588]	0.227*** [2.672]	0.301*** [3.383]								
<i>openness_EU15</i>									0.283*** [2.685]	0.180* [1.943]	0.191** [2.034]	0.286*** [2.724]				
<i>openness_NMS10</i>													0.967*** [5.263]	0.826*** [3.672]	0.859*** [3.871]	0.970*** [5.430]
<i>TechDist_EU15</i>		-0.020* [-1.925]	-0.017 [-1.633]			-0.020* [-1.900]	-0.018* [-1.668]			-0.025** [-2.409]	-0.023** [-2.180]			-0.01 [-1.091]	-0.008 [-0.834]	
<i>RDgr</i>			0.082** [2.107]	0.089** [2.284]			0.074* [1.895]	0.077** [1.969]			0.073* [1.867]	0.077** [1.963]			0.081** [2.123]	0.085** [2.251]
Number of obs.	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285
Number of groups#	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
chi2	31.77	36.24	40.62	37.4	30.56	34.4	38.37	35.25	26.46	30.94	34.81	31.06	46.16	46.89	52.87	53.73
p	0.002	0.001	0	0	0.002	0.001	0	0.001	0.009	0.003	0.002	0.003	0	0	0	0

Notes: **Measures of openness as in eq.4 in main text of the paper.** *TechDist_{t-1}*: relative productivity – VA/hours worked (in %, EU15=100%). *RDgr*: growth of R&D expenditure (with respect to GDP), in %. Constant included – not reported. Results of random effects IV estimations (G2SLS), choice of RE versus FE based on Hausman test. Trade penetration rates instrumented with their lags. Time dummies included. t-statistics in squared parenthesis, * p<0.10, ** p<0.05, *** p<0.01.

Source: own calculations

Robustness E. Trade with NMS-5 (instead of trade with NMS-10)

Table E1. Estimation results: intra-industry productivity growth versus trade penetration (trade with NMS-5 only)

	Dep.var.: Intra-industry productivity growth															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<i>exp_total_NMS5 / VA</i>	0.381*** [3.034]	0.271** [2.323]	0.318*** [2.662]	0.399*** [3.345]												
<i>imp_total_NMS5 / VA</i>					0.452*** [3.673]	0.356*** [2.666]	0.404*** [3.044]	0.474*** [4.125]								
<i>exp_interm_NMS5 / VA</i>									0.625** [2.331]	0.422* [1.709]	0.524** [2.059]	0.694*** [2.705]				
<i>imp_interm_NMS5 / VA</i>													0.947*** [3.341]	0.709** [2.399]	0.822*** [2.778]	1.003*** [3.794]
<i>TechDist_{t-1}</i>		-0.021** [-1.980]	-0.017 [-1.632]			-0.015 [-1.398]	-0.011 [-1.046]			-0.023** [-2.224]	-0.020* [-1.867]			-0.017 [-1.636]	-0.013 [-1.282]	
<i>RD_{gr}</i>			0.092** [2.351]	0.099** [2.527]			0.091** [2.354]	0.097** [2.530]			0.091** [2.289]	0.099** [2.507]			0.091** [2.345]	0.098** [2.545]
Number of obs.	285	285	285	285	285	285	285	285	285	285	285	285	1.960**	0	2.427*	1.898*
Number of groups	24	24	24	24	24	24	24	24	24	24	24	24	[1.963]	.	[1.830]	[1.733]
chi2	28.71	84.57	38.73	35.36	32.77	36.11	42.62	41.27	24.72	30.59	35.74	31.24	285	285	285	285
p	0.004	0	0	0.001	0.001	0.001	0	0	0.016	0.004	0.001	0.003	24	24	24	24

Notes: *exp_total_NMS5/VA*: ratio of exports of all goods to NMS5 to value added of reporting country; *imp_total_NMS5/VA*: ratio of imports of all goods from NMS5 to value added of reporting country; *exp_interm_NMS5/VA*: ratio of exports of intermediate goods to NMS5 to value added of reporting country; *imp_interm_NMS5/VA*: ratio of imports of intermediate goods from NMS5 to value added of reporting country; all trade penetration rates in %. *TechDist_{t-1}*: relative productivity – VA/hours worked (in %, EU15=100%). *RD_{gr}*: growth of R&D expenditure (with respect to GDP), in %. Constant included – not reported. Results of random effects IV estimations (G2SLS), choice of RE versus FE based on Hausman test. Trade penetration rates instrumented with their lags. Time dummies included. t-statistics in squared parenthesis, * p<0.10, ** p<0.05, *** p<0.01.

Source: own calculations

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