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What Determines Export Performances in High-tech Industries?

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ABSTRACT

The paper aims to identify the determinants of the exports in high-technology sectors (HT) of Visegrad countries (the Visegrad four, V-4: Poland, the Czech Republic, Slovakia, Hungary) and the core members states of the European Union (EU). Based on the augmented gravity model, we estimate the regressions on panel data of the bilateral export flows of the EU15 and V-4 with the rest of the world in 1999-2011, by employing Poisson pseudo-maximum-likelihood (PPML) estimator. The comparison of the estimations of the overall export flows with the estimates explicitly done for high-tech sectors allow us to outline the main characteristics of the existing gap in high-tech export performances of the EU 15 and V-4. Namely, estimation results find that while for the EU15 the export flows increase with similarity in physical and human capital accumulation of the trade partners, for V-4 human capital accumulation appears less significant and instead of similarity, the difference in physical capital stock increases export flows.

Keywords: international trade, high-technology, Visegrad group, gravity model.

JEL classification: F14, F15, F55

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EXECUTIVE SUMMARY

The high-technology sectors present the fastest growing sectors in international trade and provide the necessary grounds for economic growth in nowadays globalized world economy. Due to the importance of the development of the knowledge-based economy, investments in research, development, innovation and skills constitutes a key policy area for the EU. However, it is considerable that there is a gap in high-tech exports performances between the core and the new member states (NMS) of the EU since the main exporters in high-tech are presented by the core EU 15 countries. To contribute the literature, which lacks elaboration of the trade intensities in high-tech sectors among NMS, we put the research focus on the case of Visegrad countries (the Visegrad four, V-4: Poland, the Czech Republic, Slovakia, Hungary) and we aim to identify characteristics and determinants of export performances of V-4 in high-tech manufacturing industries.

We employ the augmented gravity model to estimate regressions on panel data of the bilateral export flows in high-tech sectors relatively to the overall exports of the EU15 and V-4 with the rest of the world in 1999-2011. Together with the standard gravity variables, our model controls for the technology gap and the difference in factor endowments of the trade partners. Following Silva and Tenreyro (2006), we estimate the model by PPML for the EU 15 and V-4 separately. Our estimations reveal that V-4 gain the comparative advantage on exporting the products which are not human capital intensive and neither require high R&D spending. Namely, estimation results highlight that while for the EU15 the export flows increase with the similarity in physical and human capital accumulation of the trade partner, for V-4 human capital accumulation appears less significant and instead of similarity, the difference in physical capital stock increases export flows.

Overall, our analysis suggests that in order to catch up with the EU 15 in high-tech export performances, V-4 needs to increase investment in human capital and in R&D. Additionally we recommend accumulation of physical capital stock to ensure that in the long-run physical capital endowment of V-4 will be high enough to benefit from the trade with the advanced and innovator countries.

1. INTRODUCTION

As the recent literature outlines (Hatzichronoglou, 1997; Srholec, 2005; Baesu, Albulescu, Farkas and Draghici, 2015; Eurostat, 2015) the high-technology sectors present the fastest growing sectors in international trade and provide the necessary grounds for economic growth in nowadays globalized world economy. Due to the importance of the development of the knowledge-based economy, investments in research, development, innovation and skills constitutes a key policy area for the EU. According to the data of Eurostat (2015), in 2012, the EU had almost 46 000 enterprises in high-tech manufacturing. Four countries, Germany, the United Kingdom, Italy and the Czech Republic, together account for around 53 % of the high-tech sector in the EU-28. In terms of the total value of exports, Germany was the leading exporter of high-tech products in 2013, followed by the Netherlands, France, the United Kingdom and Belgium. Thus, within the EU-28 the main exporters in high-tech are presented by the core EU 15 countries. Therefore, there is a gap in high-tech exports performances between the core and the new member states (NMS) of the EU. However the trade and export performances in the high technology sectors across the EU is not yet studied systematically.

To fill the gap in the literature, which lacks elaboration of the trade intensities in high-tech sectors among NMS, we put the research focus on the case of Visegrad countries and we aim to identify characteristics and determinants of export performances of V-4 in high-tech manufacturing industries. We employ the augmented gravity model to estimate regressions on panel data of the bilateral export flows in high-tech sectors relatively to the overall exports of the EU15 and V-4 with the rest of the world in 1999-2011. Together with the standard gravity variables, our model controls for the technology gap and the difference in factor endowments of the trade partners. Following Silva and Tenreyro (2006), we estimate the model by PPML for the EU 15 and V-4 separately. Estimation results find that while for the EU15 the export flows increase with the similarity in physical and human capital accumulation of the trade partner, for V-4 human capital accumulation appears less significant and instead of similarity, the difference in physical capital stock yields the positive and significant impacts on export flows.

The rest of the paper is organized as follows: section 2 reviews briefly the statistics around exports in high-tech sectors, section 3 presents literature review, section 4 specifies model and describes the data followed by estimation results in section 5. Finally the last section concludes findings of the analysis.

2. QUICK REVIEW OF HIGH-TECH EXPORTS

Based on the data sourced by Eurostat (NACE Rev.2, at the 3-digit level) we briefly review the R&D expenditures and the shares of different technology groups in the overall exports of the EU 15 and V-4. Additionally, we elaborate the structure of the high-tech exports for the EU15 and V-4 separately.

Figure 1 and Figure 2 present the share of high-tech products in the overall exports of the EU15 and V-4. As the figures illustrate, the share of the EU15 exceeded the one of V-4 in 2013. Although, relatively to 2004, in 2013 we observe the increase of HT share in total export of V-4 and the decrease of the EU15.

Figure 1. Share of technology sectors in the exports of EU15 and V-4 in 2013, (in %)

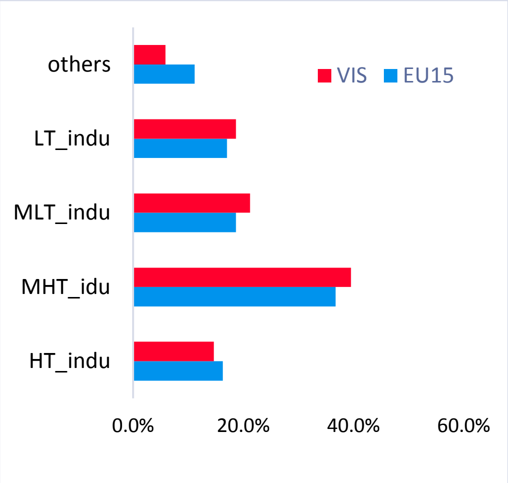
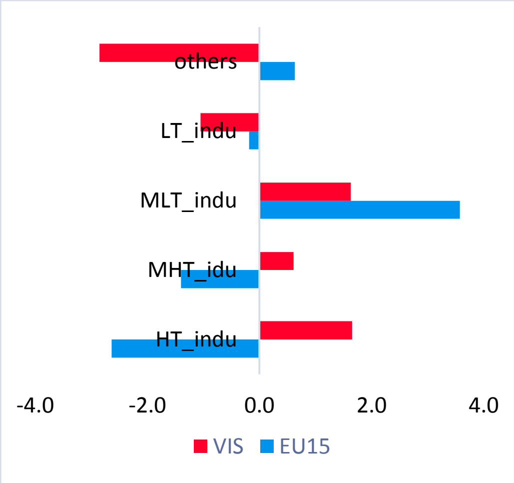


Figure 2. Change in the shares of technology sectors in exports of EU15 and V-4 over 2004-2013, (in % points)



Source: own calculations based on the data from Eurostat, (HT, NACE Rev.2, 3-digit level).

The disaggregated data of the high-tech exports by the product groups are reported in Table 1 and Figure 3. As the latter two illustrate, the EU15 mainly export pharmaceutical products (more about 37% of exports of HT comes on this product group). While exports of V-4 exhibit completely different structure. Namely, Visegrad countries mainly export consumer electronics and communication equipment.

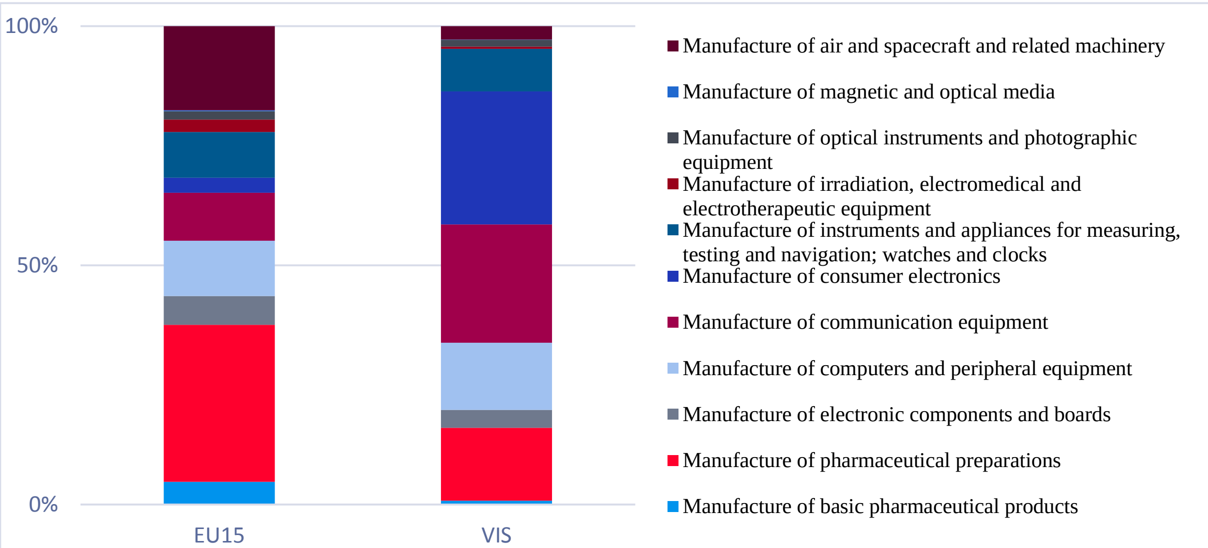
Table 1. The percentage share of different product groups in HT exports of the EU15 and V-4 in 2013.

Product groups	EU15	VIS
Manufacture of basic pharmaceutical products	4.7 %	0.8 %
Manufacture of pharmaceutical preparations	32.8 %	15.3 %
Manufacture of electronic components and boards	6.0 %	3.7 %

Manufacture of computers and peripheral equipment	11.5 %	14.1 %
Manufacture of communication equipment	10.1 %	24.7 %
Manufacture of consumer electronics	3.1 %	27.8 %
Manufacture of instruments and appliances for measuring, testing and navigation; watches and clocks	9.6 %	8.9 %
Manufacture of irradiation, electro-medical and electrotherapeutic equipment	2.6 %	0.4 %
Manufacture of optical instruments and photographic equipment	1.8 %	1.4 %
Manufacture of magnetic and optical media	0.2 %	0.1 %
Manufacture of air and spacecraft and related machinery	17.6 %	2.8 %

Source: own calculations based on the data from Eurostat, (HT, NACE Rev.2, 3-digit level).

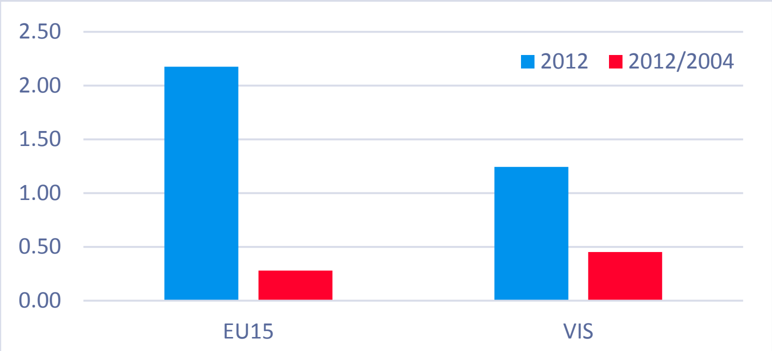
Figure 3. The structure of HT exports of the EU15 and V-4 in 2013.



Source: own calculations based on the data from Eurostat, (HT, NACE Rev.2, 3-digit level).

To characterize the difference in specialization of the EU15 and V-4 we also report the data of the R&D spending. As Figure 4 demonstrates, in 2012 R&D spending in the EU 15 was twice as large as the one of the V-4. However, the dynamics of R&D spending over the period 1999-2012 indicates that relatively to 2004, in 2012 the change in the R&D expenditure of V-4 is positive and twice larger than the change in the one of the EU 15.

Figure 4. Share of R&D expenditures in GDP in 2012 (in %) and changes in the share over 2004- 2012 (in % points)

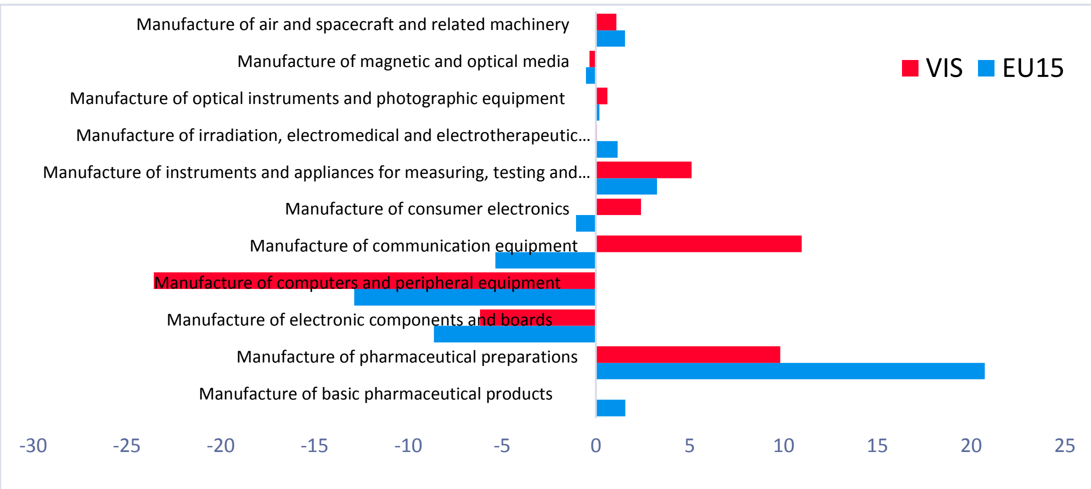


Source: World Bank, World Development Indicators database.

Since R&D expenditures are crucially important for specializing on manufacturing of pharmaceutical products, it is not surprising that the R&D expenditures of the EU 15 exceed the one of V-4. However, it is remarkable, that as the data reveal, after the EU accession, V-4 are characterized by the increased R&D expenditures.

Additionally the dynamics of disaggregated high-tech exports indicate that over 2004-2013 the decrease in HT share in overall exports of the EU15 was due to the drop in the share of electronic components, boards, computers and peripheral equipment. As for the V-4 countries, the increase might be explained by the increased shares of communication equipment and pharmaceutical preparations in their HT exports.

Figure 5. The change in the shares of different product groups in HT exports of the EU15 and V-4 in 2013, in percentage points.



Source: own calculations based on the data from Eurostat, (HT, NACE Rev.2, 3-digit level).

So as Figure 5 indicates, V-4 countries further diversify their exports on an expense of the raised shares of pharmaceutical preparations, while EU15 mainly specialize on exporting the latter and further decrease their exports in other product groups related to the electronic components.

3. LITERATURE REVIEW

The most popular methodology for empirical trade analysis is the theoretical framework of the gravity model introduced by the crucial work of Jan Tinbergen (1962) (see studies of Soloaga and Winters 2001, Ghosh and Yamarik 2004, Carrere 2006, Silva and Tenreyro 2006, Baier and Bergstand 2009, Magee, 2008, Acharya et al. 2011). The model based on a law called the “gravity equation” by analogy with the Newtonian theory of gravitation reflects the relationship between the size of economies, the amount of their trade and the distance between the trade partners, in the following form:

$$X_{ij=}\ GS_jM_j\ \emptyset_{ij}$$

where X_{ij} is the monetary value of exports from *i* to *j*, M_j controls for all importer-specific factors that make up the total importer’s demand and S_j comprises exporter-specific factors that represent the total amount exporters are willing to supply. *G* is an independent variable such as the level of world liberalization and $\emptyset_{ij}$ represents the trade costs between *i* and *j* countries. The latter is mainly represented as the country-pair-specific information such as contiguity and distance, common language, ethnic groups or borders, common memberships in regional trade agreements and tariff rates between trade partners.

The literature highlights that the high technology industries are those expanding most strongly in international trade and their dynamism helps to improve performance in other sectors due to creation of spillovers as positive externalities. Already in 1997, Hatzichronoglou stated that in the context of economic globalization, technology is a key factor in enhancing growth and competitiveness in business. Firms which are technology-intensive innovate more, penetrate new markets, use available resources more productively and as a result offer higher remuneration to the people that they employ (Hatzichronoglou, 1997).

However, the trade in high-tech sectors may demonstrate some special characteristics. Srholec (2005) outlines that the main exporters of high-technology goods might not necessarily be the developed countries with the higher spending on R&D. Instead the paper underlines the emergence of remarkably growing exports of high technology products from developing countries and explains this phenomenon by the fragmentization of the production processes. Namely, author states that the latter might be explained by the trade in the components. In other words, developing countries may import the components from the developed countries, which spend reasonable efforts on R&D, and then employ the local labour force to produce the final goods eventually for exporting purposes.

Concerning the EU, Baesu, Albulescu, Farkas and Draghici (2015) outline that the performance of high-technology sectors might play the essential role in catching-up of NMS with the core EU 15 countries. Although the trade performances in high-tech sectors is not systematically studied neither for NMS and nor particularly for V-4. However, the literature outlines some general peculiarities of the trade directions of V-4 after the EU accession. Namely, Hornok, (2010), Hunya and Richter (2011) and Foster (2011) find that surprisingly the trade among these four countries after the EU enlargement has been increased relatively more than the one with the other European countries.

Additionally, there are few recent studies which examine the impacts of technological endowments on the trade intensities by introducing new measures based on the different technological indices. Filippini and Molini (2003) construct a technological distance between trade partners based on the technological indicator (TI, Archibugi & Coco, 2002) accounting for the creation of technology, diffusion of technology and development of human skills and estimate the augmented gravity equation for trade flows among East Asian countries in 1970-2000. Estimation results indicate that the technological gap among countries strongly determines trade flows: countries tend to exchange more when there is little gap in their technology endowments.

Martinez-Zarzoso and Marquez-Ramos (2005) use the Technology Achievement Index (TAI) provided by the United Nations in its Human Development Report of 2001 to capture the performance of countries concerning technology and human knowledge. Additionally, they employ with the transport infrastructure index constructed by controlling for the kilometers of paved roads and motorways per square kilometer. Finally estimation results for a sample of 62 developed and developing countries show that the TAI index has a higher positive impact on trade than geographical or transport infrastructure variables. Additionally, the impact of technology on exports is higher for developing than for developed countries.

More recently, Wang, Wei and Liu (2010) identify the main causes of recent trade flows in OECD countries by putting an emphasis on R&D and FDI. They estimate the augmented gravity model for 19 OECD countries in 1980-1989. Estimation results find that the levels and similarities of market size, domestic R&D stock and inward FDI stock are positively related to the volume of bilateral trade, while the distance between trading countries has a negative impact. Finally, the authors conclude that their estimations support to the new economic growth theories and OECD countries face new trade trends grounded on FDI inflows and domestic R&D.

Instead of examining the impacts of technological endowment on the trade flows, we rather aim to examine the characteristics of the export performances in high-tech sectors relatively to the overall export flows for the EU15 and for V-4 separately. This approach allows us to identify the main reasons why there exists the gap between the EU15 and V-4 in high-tech exports. Additionally, instead of employing the indices for the technological endowments which have quite narrow coverage of countries and time periods due to the insufficient data availability, we control for the difference in factor endowments and introduce the different measures for technology gap.

Namely, we employ the similarity in R&D spending and the intra-industry trade (IIT) as the approximation of the technology gap between the trade partners. While none of the studies reviewed above controlled for the IIT among the independent variables we find reasonable to employ it as the relevant proxy for the shortened technology gap between the trade partners. IIT was observed in 60ties and was defined as simultaneous imports and exports of goods under the same product-level classification (Verdoorn 1960; Balassa 1966 or Grubel 1967). Theory predicts that the higher is the similarity of economic development of trade partners, the higher is IIT among them (Helpman and Krugman 1985).

Overall, our analyses aims to cover the gap in the literature in two directions: first, we examine the export performances of the EU countries in high-tech sectors, separately for the old and the new member states to provide comparisons; second, we aim to identify the determinants of the high-tech exports relatively to the exports in all sectors by controlling for the difference in factor endowments and the technology gap between the trade partners.

4. MODEL SPECIFICATION AND DATA DESCRIPTION

Although the gravity model is already a commonly accepted and a standard tool to study the trade flows, the specification of the equation for estimation purposes differs according to the approaches of different authors. The most remarkably, Silva and Tenreyro (2006) in their seminal paper have raised a problem that has been ignored so far by both the theoretical and applied studies. In particular they argued, that the logarithmic transformation of the original model is not relevant approach to estimate elasticities. Namely, the multiplicative trade models with multiplicative error do not satisfy the assumption of the homoscedasticity of the error term since there is dependency between the error term of transformed log-linear model and the regressors, which finally causes inconsistency of the ordinary least squares estimator or the random and fixed effects estimator.

As an alternative, authors propose the estimation of the gravity model in levels using the PPML estimator. Besides tackling with the problem of heteroscedasticity of the error term, the estimator deals with the zero value observations in trade flows. Additionally, unlike to the standard Poison approach, PPML does not require the data to be Poison type, in other words, that it does not require the dependent variable to be an integer. Finally, PPML allows to identify effects of time invariant factors. The latter is very important feature for our analyses, since we aim to test the effects of several dummy variables indicating memberships in different regional agreements together with the time dummy controlling for the occurrence of crisis during the estimation period.

Following the contribution of Silva and Tenreyro (2006), we analyse the trade of the all EU members with the rest of the world based on the following estimation equation:

$$X_{ijt} = \beta_0 + \beta_1 \ln|Y_{it} - Y_{jt}| + \beta_2 \ln(Pop_{it}) + \beta_3 \ln(Pop_{jt}) + \beta_4 \ln(Z_{ij}) + \beta_5 D_{ijt} + \beta_6 D'_{ij} + \beta_7 \ln(\mathrm{sim}R\&D_{ijt}) + \beta_8 IIT_{ijt} + \beta_9 \ln(diffK_{ijt}) + \beta_{10} \ln(diffH_{ijt}) + \mu_{ij} + \varepsilon_{ijt}$$

where X_{ijt} is the export flows from *i* to *j* at time *t* either in all the trade sectors or in high-tech manufacturing industry sectors. As for the right hand side of the equation, we include independent variables approximating the market size, geography, technological gap and the difference in factor endowments between the trade partners. Namely, marker related variables are $|Y_{it} - Y_{jt}|$, which stands for the absolute value of the difference between the current GDPs of the importer and exporter countries and Pop_{it} and Pop_{jt}, which indicate populations at time *t* in the reporter and partner countries respectively. Geographical variables are presented by Z_{ij}, which is the non-binary but time invariant information such as distance between the exporter and importer countries; D'_{ij} which stands for contiguity and equals one when the trade partners share the common border and zero otherwise and D_{ijt} which presents a dummy for membership in the EU which equals one if a trade partner belongs to the EU and zero otherwise.

The remaining variables such as $\mathrm{sim}R\&D_{ijt}$ and IIT_{ijt} present proxies for the technology gap between the trade partners. Namely, $\mathrm{sim}R\&D_{ijt}$ stands for the similarity in the R&D expenditures [1] of the trade

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[1] The similarity index for expenditures on R&D is calculated as follows: $simRD_{ijt} = 1 - \frac{|RD_{it} - RD_{jt}|}{(RD_{it} + RD_{jt})}$, where RD_{it} and RD_{jt} represent expenditures on R&D of a reporter country *i* and a partner country *j* at time *t*.

partners *i* and *j* at time t and IIT_{ijt} controls for IIT either in all sectors or only in the high-tech sectors between exporter and importer countries at time t [2]. Finally, $diffK_{ijt}$ and $diffH_{ijt}$ stand for factor endowment and are calculated as the absolute value of the difference between the physical and human capital stocks per capita[3] between the trade partners *i* and *j* at time *t*. As for the last two components of the equation, μ_{ij} is the time invariant individual characteristics for each pair of trade partners and ε_{ijt} is the error term that is assumed to be normally distributed with mean zero. Exporter countries are the all 28 EU members while as importers together with the EU countries, we take the rest of the world consisting of 234 countries in our sample.

The data of the export and trade flows in high technology manufacturing industries sectors come from the Eurostat based on the Statistical Classification of Economic Activities in the European Community (NACE Rev.2) at the 3-digit level for compiling groups. Namely, statistics on high-tech industry (HT) comprises of economic, employment and science, technology and innovation (STI) data which describe manufacturing applied based on the technological intensity. Three approaches are used to identify technology-intensity: sectoral, product and patent approach. To analyze the significance of HT in trade, we use the sectoral approach. It is a particular aggregation of the manufacturing industries, more precisely, according to the level of their technological intensity (R&D expenditure/value added), manufacturing activities are grouped to 'high-technology' (HT), 'medium high-technology' (MHT), 'medium low-technology' (MLT) and 'low-technology' (LT)[4].

The data of the current GDP levels in millions of US dollars and expenditures on R&D as the percentage of the GDP are included from the World Development Indicators database complied by the World

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[2] We calculate IIT by the Grubel-Lloyd (*GL*) index as follows: $$IIT_{R,P,j,t} = 1 - \frac{\sum_R \sum_P \sum_{i \in j} \left| X_{RPit} - M_{RPit} \right|}{\sum_R \sum_P \sum_{i \in j} (X_{RPit} + M_{RPit})} \cdot 100$$, where R stands for a reporter, P for a partner and i for a commodity.

[3] Namely the differences are calculated as follows: $diff(K) = \left|\frac{K_{it}}{P_{it}} - \frac{K_{jt}}{P_{jt}}\right|$, $diff(H) = \left|\frac{H_{it}}{P_{it}} - \frac{H_{jt}}{P_{jt}}\right|$, where K_{it} and K_{jt} represent the physical capital stock, H_{it} and H_{jt} – human capital index and P_{it} and P_{jt} population of a reporter country *i* and a partner country *j* at time *t*.

[4] See the detailed information on: http://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an3.pdf.

Bank. The data for the physical and human capital stocks are taken from the Penn World Tables version 8.0. (PWT 8.0). The data for the other variables such as distance and contiguity are taken from the CEPII database. According to the data availability, the sample covers the period from 1999 to 2011.

Table 2 reports, the employed variables grouped into the three groups as described above.

Table 2. Variables employed in the model

Variable Name	Description	Source	Expected sign
lndiff_gdp	Natural logarithm of the absolute difference between the current GDPs of the importer and exporter countries	WDI	-
ln_pop_r	Natural logarithm of population of a reporter country	WDI	+
ln_pop_p	Natural logarithm of population of a partner country	WDI	+
ldistance	Natural logarithm of geographical distance between the capital of the trading partners	CEPII	-
contig	Dummy variable standing for the neighboring countries	CEPII	+
EU_par	Dummy variable denoting the EU membership of a partner country	authors	+
ln_iit	Natural logarithm of the intra-industry trade index in overall exports	authors calculation	
lniit_high	Natural logarithm of the intra-industry trade index in high-tech exports	authors calculation	
ln_sim_RD	Natural logarithm of the similarity index of R&D spending	WDI	+
ln_diff_ck	Natural logarithm of the absolute difference between the per capita physical capital stocks of a reporter and a partner country	PWT 8.0.	-
ln_diff_hc	Natural logarithm of the absolute difference between the per capita human capital stocks of a reporter and a partner country	PWT 8.0.	-

Source: own compilation.

Some descriptive statistics of the variables of interest together with correlation matrix are provided by Table 5 and Table 6 in Appendix. It is remarkable that correlation matrix does not report the problem of the colliniarity between the independent variables.

5. ESTIMATION RESULTS

As discussed in the previous section, we estimate the augmented gravity model by PPML estimator, where all the variables, except the dependent variable and dummies, are taken in logarithms. The latter two are taken in levels. We run regressions on export flows in all sectors as well as only in high-technology sectors for the EU15 and Visegrad countries separately.

Table 3 reports the estimation results. First two columns provide estimations for the export flows in all and in high-tech sectors for the EU 15. Similarly, the third and the fourth columns provide estimations for the export flows in all and in high-tech sectors for V-4.

Table 3. Estimation results, overall and high-tech exports of the EU15 and V-4

	(EU 15) all sectors	(EU 15) high-tech	(V-4) all sectors	(V-4) high-tech
ln_gdpdiff	-0.107***	-0.201***	-0.0469	0.0851
	(-9.92)	(-15.70)	(-1.66)	(1.82)
ln_pop_r	0.501***	0.478***	0.473***	0.0291
	(41.24)	(26.46)	(16.97)	(0.77)
ln_pop_p	0.509***	0.538***	0.636***	0.607***
	(58.52)	(43.22)	(31.17)	(24.45)
contig	0.372***	0.248***	0.211**	-0.146
	(11.36)	(5.24)	(2.63)	(-1.29)
ldistance	-0.405***	-0.396***	-0.718***	-0.579***
	(-24.01)	(-17.58)	(-20.48)	(-9.10)
EU_par	0.245***	0.349***	0.818***	1.401***
	(8.12)	(7.56)	(16.08)	(15.13)
ln_iit	0.776***		0.573***	
	(32.48)		(15.90)	
lniit_high		0.490***		0.284***
		(15.12)		(6.02)
ln_sim_RD	0.277***	0.503***	-0.0823	0.371***
	(8.47)	(11.27)	(-1.01)	(3.66)
ln_diff_hc	0.0250***	0.0407***	0.0179	-0.0205
	(3.58)	(4.40)	(1.06)	(-1.10)
ln_diff_ck	-0.101***	-0.119***	0.101***	0.0989**
	(-10.64)	(-8.09)	(4.50)	(3.04)
cons	15.87***	17.04***	13.33***	12.29***
	(88.29)	(65.99)	(42.41)	(24.79)
N	140155	13182	30989	2912

t statistics in parentheses
Significance at the 10%*, 5%** and 1%*** levels

Source: own calculations, Stata (2013).

As Table 3 illustrates, the absolute difference between the current GDPs of trade partners yields negative sign already at the 1% significance level for all sectors as well as for high-tech sectors in case of the EU 15, however is not statistically significant for V-4. This finding indicates that the overall economic similarity with the trade partner is important only for the EU 15 export performances. Population of reporters yields positive sign at the 1% significance level, implying the positive impacts of possible increase in the domestic production due to the larger labor supply. However, the latter is not statistically significant only in case of V-4 exports in high-tech sectors. This result gives us an intuition to state that relatively to the EU 15, the population increase in V-4 countries is associated more to the unskilled rather than skilled labour supply and that is why an increase in population is not contributive for the export performances in high-tech sectors. Population of the partner country is positive at the 1% significance level for all sectors and for both group of countries and thus indicates that the possible expansion of the demand on a given trade partner's market increases exports of the EU 15 and V-4.

Distance yields the negative sign as expected at the 1% significance level for all the countries and all the sectors. The coefficient of the dummy standing for contiguity also yields expected sign and is statistically significant with the only exception of the high-tech sectors for V-4. This finding implies that unlike to the EU 15, V-4 might not necessarily export high-tech products to the neighboring countries. The dummy for the EU partnership of a trade partner yields positive sign as expected and is statistically significant at the 1% significance level with remarkably high magnitude for V-4. This finding indicates that the EU enlargement had the positive impacts on export performances for all the sectors for both: the old and the new EU members states, however positive outcomes are higher for V-4.

Our estimations also find intra-industry trade to be positive and statistically significant for all the sectors for both, the EU 15 and V-4. However, the magnitudes of the coefficients are higher for the overall export flows than for the exports in high-tech sectors, which implies that technology gap is larger in high-tech sectors compared to the aggregated overall exports. Additionally, the magnitudes of the coefficients are twice larger for the EU15 than the ones for V-4. The latter implies, that the technology gap between the EU 15 and its trade partners is smaller than the gap between V-4 and its trade partners. Additionally, similarity in R&D spending with the trade partner yields positive and statistically significant coefficients for all the sectors of the EU15, although the magnitude of the coefficient for high-tech sectors is twice as large as the one of the overall sectors. This implies that R&D expenditures have higher explanatory power on high-tech exports of the EU 15. However, in case of V-4, R&D spending yields positive and statistically significant coefficient only for the high-tech sectors. The latter implies that overall exports of V-4 are based on the products which do not require the high R&D spending. This intuition is confirmed by the rest of the estimations.

Namely, the difference in per capita human capital endowment is statistically significant only for the EU 15 with twice larger magnitude for exports in high-tech sectors than the overall exports. However, human capital endowment of V-4 is not found to be statistically significant for none of the technology sectors. This finding is also in line with the finding concerning population. As our estimations reported, population increase was not significant only for V-4 and only for high-tech sectors. Therefore, once human capital endowment is not found to be statistically significant to explain export performances of V-4 at all, our intuition to state that population increase is associated with the unskilled labor supply in V-4 is confirmed. Besides, the difference in per capita physical capital accumulation is statistically significant for all the sectors of both: the EU 15 and V4. However, while for the former it yields negative sign for the latter it yields the positive sign. This finding implies, that while for the EU15 the trade is increasing with the countries owning similar physical capital stock, for V-4, the trade is determined actually by the difference in physical capital accumulation. So, our results show that V-4 countries might trade either with the developing countries which own less physical capital than V-4 or with more advanced countries which own larger physical capital stock than V-4.

To identify explicitly whether the difference in physical capital stock is more important for exporting to more advanced countries or less advanced ones, we split the trade partners into high and low income country groups and again run regressions only for export flows of V-4 in high-tech sectors. Estimation results are reported in Table 4.

Table 4. Estimation results, exports in high-tech sectors of V-4, with high and low income countries

	(V-4) high-income	(V-4) low-income
ln_gdpdiff	0.0468	0.310
	(0.97)	(1.28)
ln_pop_r	0.0532	0.155
	(1.34)	(1.34)
ln_pop_p	0.734^{***}	0.620^{***}
	(24.14)	(8.80)
contig	-0.166	1.159^{***}
	(-1.49)	(4.22)
ldistance	-0.608^{***}	-1.399^{***}
	(-10.04)	(-8.14)
EU_par	1.026^{***}	
	(11.23)	
lniit_high	0.206^{***}	0.0340
	(4.04)	(0.72)

ln_sim_RD	0.513***	0.0178
	(4.56)	(0.09)
ln_diff_hc	-0.0190	-0.0351
	(-1.04)	(-0.53)
ln_diff_ck	0.130***	0.535**
	(3.72)	(3.20)
cons	12.35***	9.471***
	(27.18)	(3.95)
N	2223	685

t statistics in parentheses
Significance at the 10%*, 5%** and 1%*** levels

Source: own calculations, Stata (2013).

As Table 3 indicates, our estimations stay robust, since all the variables yield expected signs again. The absolute difference between the current GDPs of trade partners and population in a reporter country are not statistically significant as in the previous case. The population of a partner country is again positive and statistically significant at the 1% significance level for both, high and low income trade partners. Contiguity yields the expected sign as in the previous case and is statistically significant only for the low income trade partners. Distance has negative sign and is statistically significant at the 1% significance level for both income category countries, however magnitude for the low-income trade partners are obviously larger. This implies that the low-income countries less likely afford imports from the distant countries. The EU membership of a partner country again yields the positive and statistically significant coefficient and therefore indicates the positive impacts of the EU enlargement on export performances.

IIT is positive and statistically significant at the 1% significance level only for the exports with the high-income countries. Likewise, similarity in R&D spending is positive and statistically significant only for the exports with high income countries. These findings show that the smaller technology gap and R&D spending is important only for the exports with the high-income countries. However as in the previous case, the human capital endowment does not have explaining power neither for the exports with high-income and nor for the exports with the low-income trade partners.

Finally, the per capita physical capital accumulation yields again the positive sign and is statistically significant for both high and low income countries. However the magnitude of the coefficient standing for the low income countries is four times higher than the one standing for the high income countries. Therefore this finding implies that the difference in per capita physical capital accumulation increases high-tech exports more to the low-income countries than to high-income ones. On the other hand, since the coefficient is positive and statistically significant for high-income countries as well, we can conclude that the difference in physical capital endowment also increases high-tech exports of V-4 to the advanced countries.

6. CONCLUSIONS

The paper aimed to identify the main determinants of the export performances in high-tech sectors of V-4 relatively to the EU 15. Based on the augmented gravity model, we estimated the regressions on panel data of export flows of the EU15 and V-4 with the rest of the world over the time period 1999-2011. Together with market and geography related variables, we controlled for the technology gap and the difference in factor endowments of the trade partners. We followed the recent advancement in the empirical trade literature and provided estimation results by PPML estimator.

Estimation results indicated that while for the EU15 the export flows increase with the similarity in physical and human capital accumulation of the trade partner, for V-4 human capital accumulation appears less significant and instead of similarity, the difference in physical capital stock yields the positive and significant impacts on export flows. Additionally, after grouping the trade partners into the low and high income countries, the regression results revealed that the difference in physical capital endowment has four times higher positive impacts on high-tech exports with the low-income countries than the high-income countries. The latter, together with our statistical analysis provided in section 2, might imply that V-4 mainly export communication equipment and consumer electronics to the less developed countries which cannot afford buying the better quality products from the more advanced producers which create innovations in high-technology.

Overall, our findings demonstrate that V-4 gain the comparative advantage on exporting the products which are not human capital intensive and neither require high R&D spending. Therefore our analysis suggests that in order to catch up with the EU 15 in high-tech export performances, V-4 needs to increase investment in human capital and in R&D. Additionally in order to shift exports from low-income countries to the high-income countries, V-4 should also increase physical capital accumulation. This will ensure that in the long-run physical capital endowment of V-4 will be high enough to benefit from the trade with the advanced and innovator countries.

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APPENDIX

Table 5. Summary statistics

Variable	Mean	Standard Deviation	Min	Max	Observations
Ex_v_T	80955	689751	0	54700000	774713
diffgdp	23040	15079	2	112786	696876
pop_R	26	26	0	83	692491
pop_P	47	155	0	1324	588201
contig	0	0	0	1	754735
distcap	5716	3937	60	19586	754735
EU_par	0	0	0	1	774713
iit_T	0	0	0	1	771738
iit	0	0	0	1	774668
sim_RD	1	0	0	1	275716
diff_hc	1	2	0	15	501275
diff_ck	57365	36908	2	273033	588201
high_inc	0	0	0	1	774713
low_inc	0	0	0	1	774713

Source: own calculations, Stata (2013).

Table 6. Correlation matrix

	diffgdp	pop_R	pop_P	contig	distcap	EU_par	iit_T	iit	sim_RD	diff_hc	diff_ck	high_inc	low_inc
diffgdp	1												
pop_R	-0.008	1											
pop_P	0.0432	-0.0152	1										
contig	-0.157	0.0356	-0.0443	1									
distcap	0.0234	0.038	0.1523	-0.2438	1								
EU_par	-0.0858	-0.0488	-0.1644	0.1684	-0.5464	1							
iit_high	-0.1278	0.1669	-0.0009	0.277	-0.1998	0.2789	1						
iit	-0.184	0.266	-0.0223	0.4212	-0.3402	0.4471	0.5296	1					
sim_RD	-0.3725	-0.05	0.1166	0.1918	-0.2641	0.2604	0.2246	0.3285	1				
diff_hc	0.1655	-0.1759	-0.0444	-0.0499	-0.0696	0.0606	-0.1072	-0.15	0.0192	1			
diff_ck	0.7352	0.025	0.0899	-0.1575	0.1302	-0.1615	-0.1498	-0.213	-0.3777	0.1006	1		
high_inc	-0.1806	-0.0411	-0.2599	0.095	-0.1487	0.4385	0.2193	0.3352	0.2924	0.1402	-0.2592	1	
low_inc	0.1803	0.0411	0.2607	-0.0951	0.1505	-0.4376	-0.219	-0.3348	-0.2927	-0.14	0.2594	-0.9979	1

Source: own calculations, Stata (2013).