

## High-Tech Export from the V4 Countries: Structure and Factors

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### ABSTRACT

**Objective:** The purpose of this article is to verify the relation between the value of high-tech export and the value of intellectual capital assets.

**Research Design & Methods:** At the first stage of the study, an analysis of the value and structure of high-tech export in the V4 countries was performed. At the second stage, the Synthetic Intellectual Capital Asset Index (ICA) was calculated using the Perkal index. At the last stage, in order to examine the relation between the value of high-tech export and the value of intellectual capital assets, an estimation of panel models for selected variables was performed.

**Findings:** The results of analysis show that the value of high-tech export from the V4 countries varies, and the V4 countries score lower in the ranking of EU countries arranged by the value of ICA is than in the ranking of EU countries arranged by the value of high-tech export.

**Implications & Recommendations:** The relation between the value of high-tech export and the value of ICA was negative for the V4 countries, but models created with the data for all EU countries showed a positive correlation. Identify the causes of such a situation could be very valuable.

**Contribution & Value Added:** Linking intellectual capital assets to the high-tech export could be helpful to find the sources of the high level of exports in this sector.

**Article type:** research paper

**Keywords:** export; high-tech; knowledge-based economy; intellectual capital

**JEL codes:** F14

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## INTRODUCTION

According to the *Central Europe fit for the future Visegrad Group ten years after EU accession* (2014, p. 5) report, ‘the combined GDP of the Visegrad Group countries (V4)<sup>1</sup> already makes them the world’s 15th-biggest economy.’ In the knowledge-based economy, the high-tech sector is developing dynamically and is usually an important export sector. The manufacturing of high-tech products requires specific assets, necessary to invent and develop those products.

The purpose of this article is to verify the relation between the value of high-tech export and the value of intellectual capital assets. This was achieved by meeting the following operational purposes:

- analysis of the value and structure of high-tech export in the V4 countries,
- calculation of intellectual capital assets for EU countries and the analysis of the value of intellectual capital assets in the V4 countries,
- examination of relations between value of high-tech export and the value of intellectual capital assets.

The research hypotheses were:

- All V4 countries have the same performance of the value of export in high-tech sector.
- For all V4 countries, the value of high-tech export in intra-EU trade is higher than in extra-EU trade.
- The value of intellectual capital assets has a positive influence on the high-tech export.

The value of intellectual capital assets was calculated using the standardized sum method (the Perkal index). To examine the relation between the value of high-tech export and the value of intellectual capital assets, panel models were estimated. The data for EU-28 countries were collected from the Eurostat database and the World Bank database for the period of 2007-2012.

## LITERATURE REVIEW

The category of intellectual capital was established for the first time in the field of accounting (Edvinsson & Malone, 1997). The term *intellectual capital* was mentioned for the first time in M. Kronfeld and A. Rock’s (1958) article and in the personal letter from J.K. Galbraith to M. Kalecki written in 1969 (quoted in Hudson, 1993, p. 15)<sup>2</sup>. The first definition of intellectual capital of a nation was created in 1996 by C. Stenfelt and M. Jerehov, in collaboration with L. Edvinsson, followed by a study of intellectual capital in Israel conducted in 1998 by E. Pasher, with the support of L. Edvinsson and C. Stenfelt (Edvinsson & Stenfelt, 1999)<sup>3</sup>. In 2001, N. Bontis (2002) conducted a research on intellectual capital in Arab countries and proposed the following definition: ‘The intellectual capital of a nation includes the hidden values of individuals, enterprises, institutions, communities and regions that are the current and potential sources for

<sup>1</sup> The Visegrad countries (V4) include: the Czech Republic, Hungary, Poland and Slovakia.

<sup>2</sup> To a review of intellectual capital models see: N. Bontis (2001), L. Alcaniza, F. Gomez-Bezares & R. Roslenderb (2011).

<sup>3</sup> In 2011 L. Edison and C.Y. Lin published the book with reports on intellectual capital indicators for 40 countries.

wealth creation.’ D. Andriessen and C. Stam (2005) published the results of a study measuring the intellectual capital of EU-15 countries. They proposed to measure the components of intellectual capital (human capital, structural capital and relational capital) from three different perspectives: present (assets), future (investments), and past (effects) (Andriessen & Stam, 2005, pp. 5-6). ‘Human capital is defined as the knowledge, education and competencies of individuals in realizing national tasks and goals’ (Bontis, 2004, p. 7). ‘Process capital’<sup>4</sup> is defined as the non-human storehouses of knowledge in a nation which are embedded in its technological, information and communications systems as represented by its hardware, software, databases, laboratories and organizational structures which sustain and externalize the output of human capital’ (Bontis, 2004, p. 8). ‘Market capital’<sup>5</sup> is defined as the intellectual capital embedded in national intra-relationships. Market capital represents a country’s capabilities and successes in providing an attractive, competitive solution to the needs of its international clients, as compared with other countries’ (Bontis, 2004, p. 9).

The components of intellectual capital are to some extent similar to the four pillars of knowledge-based economy, which were proposed by the World Bank (Chen & Dahlman, 2005, p. 4):

- Education and Training,
- Information Infrastructure,
- Economic Incentive and Institutional Regime,
- Innovation Systems.

Knowledge-based economies are defined by the OECD (1996, p. 6) as ‘economies which are directly based on the production, distribution and use of knowledge and information’. Knowledge-based economy is characterized by fast development in sectors related to the development of science, the use and creation of knowledge (high-technology industries) and information society services (Nowakowska, Przygodzki & Sokołowicz 2011, p. 31). What is more, currently the knowledge-based economy is transforming towards the entrepreneurial economy (Wach, 2012, p. 200). OECD (1997, p. 8) defined high-tech industries by the following criteria: R&D intensity, scientific and technical personnel, the technology embodied in patents, licenses and know-how, strategic technical co-operation between companies, the rapid obsolescence of the knowledge available, quick turnover of equipment, etc. The production in high-tech sector includes the following groups of products (OECD, 1997, p. 9):

- aerospace (HT1 – abbreviations used in graphs),
- computers-office machines (HT2),
- electronics-telecommunications (HT3),
- pharmacy (HT4),
- scientific instruments (HT5),
- electrical machinery (HT6),
- chemistry (HT7),
- non-electrical machinery (HT8),
- armament (HT9).

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<sup>4</sup> At the national level ‘process capital’ is defined as ‘structural capital’.

<sup>5</sup> At the national level ‘market capital’ is defined as ‘relational capital’.

## MATERIAL AND METHODS

The data was collected for EU-28 countries, for the period of 2007-2012. The value of high-tech export in this article is presented in millions of euro, and Eurostat is the data source.

The presentation of intellectual capital assets was adopted from D. Andriessen and C. Stam research (2005). The indicators for human capital assets, structural capital assets and relational capital assets were selected according to data availability (table 1).

**Table 1. List of indicators used in the analysis**

Components of the intellectual capital	Indicator	Source (the code of dataset)
Human capital assets	HCA_1: Percent of persons with upper secondary or tertiary education attainment (%) aged 25 to 64	Eurostat (edat_lfse_08)
	HCA_3: Percent of persons participated in education and training aged 25 to 64	Eurostat (trng_lfse_01)
	HCA_4: Researchers as percentage of total employment	Eurostat (rd_p_perslf)*
	HCA_5: Employment rate (15 to 64 years)	Eurostat (lfse_emp_a)
	HCA_6: Employment in knowledge-intensive activities as percentage of total employment	Eurostat (htec_kia_emp and htec_kia_emp2)
Structural capital assets	SCA_1: Percentage of households who have Internet access at home	Eurostat (isoc_ci_in_h)
	SCA_2: Percentage of enterprises who have access to Internet	Eurostat (isoc_ci_in_e and isoc_ci_in_en2)
	SCA_3: Number of patent applications to the European Patent Office (EPO) per million inhabitants	Eurostat (pat_ep_ntot)*
	SCA_5: Number of scientific and technical journal articles	WorldBank (IP.JRN.ARTC.SC)*
	SCA_9: Number of days needed to start a new business	WorldBank (IC.REG.DURS)
Relational capital assets	RCA_3: Foreign students as percentage of all students	Eurostat (hrst_fl_tefor)*
	RCA_4: International outgoing calls (1000 minutes)	Eurostat (isoc_tc_cal)*
	RCA_5: Number of arrivals of non-residents at tourist accommodation establishments	Eurostat (tour_occ_arnat)*

\* missing data were eliminated by imputation, in the case of shorter time series were used to extrapolate the trend, taking into account the method giving the lowest ex-post error evaluation,

Source: own elaboration based on (Andriessen, Stam, 2005)

The indicators were standardized according to the following formula (Juchniewicz & Tomczyk, 2013, pp. 50-51):

$$z_{ij}^t = \frac{x_{ij}^t - \bar{x}_{ij}}{s_{ij}} \text{ for } (i=1, \dots, n; j=1, \dots, m; t=1, \dots, 6) \quad (1)$$

where:

$x_{ij}^t$  - value of  $j$  indicator for  $i$  country in  $t$  period

$\bar{x}_{ij}$  - value of arithmetic mean for  $j$  indicator for  $i$  country

$s_{ij}^t$  - value of standard deviation of  $j$  indicator

SCA\_9 was standardized according to the following formula for the destimulant:

$$z_{ij}^t = -\frac{x_{ij}^t - \bar{x}_{ij}}{s_{ij}^t} \quad (i=1, \dots, n; j=1, \dots, m; t=1, \dots, 6) \quad (2)$$

where:

- $x_{ij}^t$  - value of  $j$  indicator for  $i$  country in  $t$  period
- $\bar{x}_{ij}$  - value of arithmetic mean for  $j$  indicator for  $i$  country
- $s_{ij}^t$  - value of standard deviation of  $j$  indicator

In the next step, the synthetic intellectual capital assets index (ICA) for EU countries was calculated using the standardized sum method (Perkal index), with the same weights assigned to each indicator (Malina, 2004, p. 74):

$$Z_i = \frac{1}{m} \sum_{j=1}^m z_{ij} \quad \text{for } (i=1, \dots, n) \quad (3)$$

where:

- $Z_i$  - value of synthetic index of  $Z$  for  $i$  country

The value of the synthetic intellectual capital assets index ranges from -3 to 3, where -3 is assigned to a country with the lowest value of intellectual capital assets, and 3 is assigned to a country with the highest value of intellectual capital assets.

To examine the relation between the value of high-tech export and the value of intellectual capital assets, the estimation of panel models for selected variables was performed (table 2).

**Table 2. Variables for estimation of panel models**

Type of variables	Variable		Source (the code of a dataset)
response variables	Y1	In of value of export in high-tech sector intra-UE	Eurostat (htec_trd_tot4)
	Y2	In of value of export in high-tech sector extra-UE	Eurostat (htec_trd_tot4)
explanatory variables	X1	Total intramural R&D expenditure in euro per inhabitant	Eurostat
	X2	Labour cost index (country weights)	Eurostat (lc_lci_r1_cow)
	X3	Labour productivity as percentage of EU27 total (based on PPS per employed person)	Eurostat (nama_aux_lp)
	X4	In gross value added	Eurostat (nama_r_e3vab95r2)
	X5	Synthetic intellectual capital assets index	Own calculations based on data by Eurostat and WorldBank (table 1)

Source: own elaboration

The estimation was performed according to the following outline (Batagi, 2005):

1. Estimation of the total regression model (pooled) according to the general formula:

$$Y_{it} = C + \alpha_i * X_{it} + \alpha_i * X_{it} + \dots + \alpha_j * X_{jk}; i=1, \dots, N; t=1, \dots, T \quad (4)$$

2. Execution of the significance test for individual random effects, allowing to choose between the pooled model, and the model with fixed effects (FE).

3. Execution of the BP test, allowing to choose between the pooled model, and the model with random effects (RE).
4. Execution of the Hausman test, allowing to choose between the FE model and RE.
5. Estimation of FE model according to the general formula:

$$Y_{it} = \beta' X_{it} + \alpha_i + \lambda_t + u_{it}; i=1, \dots, N, t=1, \dots, T \quad (5)$$

6. Estimation of RE model according to the general formula:

$$Y_{it} = \beta' X_{it} + \alpha_{it} + \lambda_t + u_{it}; i=1, \dots, N, t=1, \dots, T \quad (6)$$

At the first stage, estimation was performed only for V4 countries. At the second stage, estimation was performed for all EU-28 countries.

## RESULTS AND DISCUSSION

### Value and Structure of High-Tech Export in V4 Countries

The average value of high-tech export in intra-EU-28 trade in 2012 reached 11 725 million EUR. From all of the V4 countries, only the Czech Republic achieved higher than the EU-28 average, which was 14 858 million EUR. From all of the V4 countries, the lowest value of high-tech export in 2012 was reported in Slovakia (4 292 million EUR) and Poland (5 662 million EUR). In 2007, the value of high-tech export in Hungary was similar to the value of export in the Czech Republic, but after 2010, the value of export in the Czech Republic increased significantly, but stayed almost on the same level in Hungary: 9 488 million EUR in 2007 and 8 559 million EUR in 2012 (figure 1).

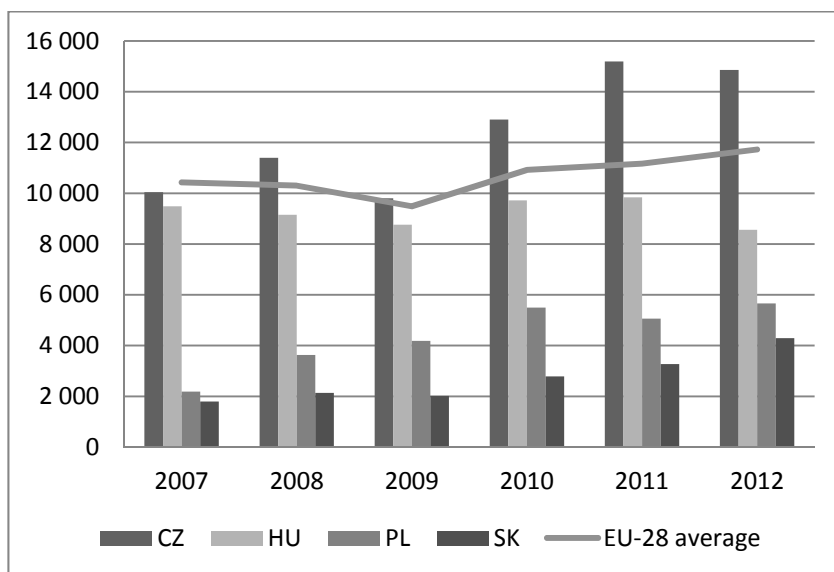


Figure 1. Export in high-tech sector from V4 countries to EU countries and EU-28 average in 2007-2012 period in million euros

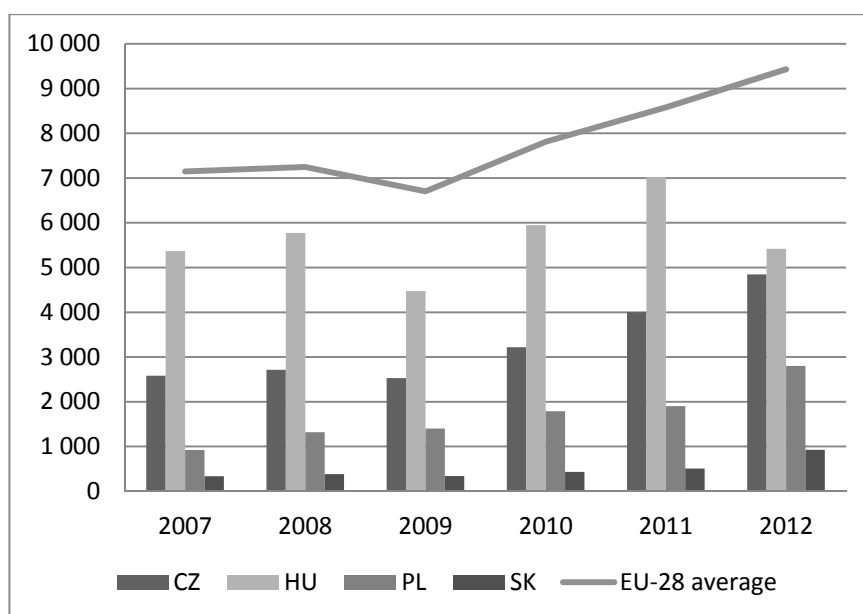
Source: Eurostat (htec\_trd\_tot4)

The high increase in the value of high-tech export in the Czech Republic is confirmed by the position of the country in a ranking of the EU countries for the analyzed period. From all of the V4 countries, the Czech Republic achieved the highest position in the ranking: it ranked 8th in 2007 and 6th in the following years, from 2008 to 2012. Poland and Slovakia went up 3 spots during the analyzed period, but they scored much lower compared to the Czech Republic. Slovakia ranked 14th, Poland ranked 13th position in 2012. In contrast, Hungary's position fluctuated during the analyzed period (table 3).

**Table 3. V4 countries position in the ranking of EU countries arranged according to the values of high-tech export in intra-EU trade in 2007-2012**

Country	2007	2008	2009	2010	2011	2012
CZ	8	6	6	6	6	6
HU	9	9	9	8	8	10
PL	16	16	15	13	13	13
SK	17	17	17	16	15	14

source: own calculations based on Eurostat data (htec\_trd\_tot4)



**Figure 2. Export in high-tech sector from V4 countries to non-EU countries and UE-28 average in 2007-2012 period in million euros**

Source: Eurostat (htec\_trd\_tot4)

The average value of high-tech export for all EU countries in extra-EU trade in 2012 reached 9 433 million EUR. The value of high-tech export from V4 countries to non-EU countries was significantly lower than the EU-28 average. In 2012, the lowest value was achieved by Slovakia (926 million EUR), followed by Poland (2 800 million EUR). From all of the V4 countries, Hungary had the highest value of high-tech export to non-EU countries. In 2012, Hungarian export reached 5 417 million EUR, but it was fluctuating

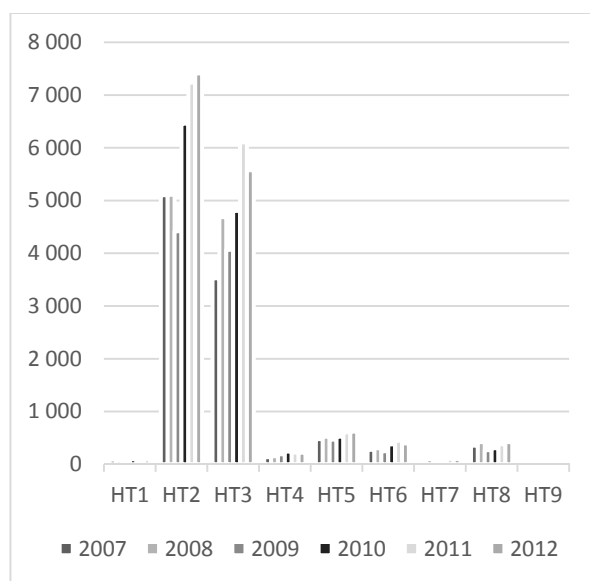
during this period. When it comes to the Czech Republic, the value of high-tech export to non-EU countries systematically increased from 2 584 million EUR in 2007 to 4 848 million EUR in 2012 (figure 2).

The relatively large value of high-tech export in Hungary in extra-EU trade is confirmed by Hungary's position in the ranking of EU countries. From all of the V4 countries Hungary achieved the highest position in the ranking: the 10th in 2012, followed by the Czech Republic, which ranked 11th in 2012. The ranks of Slovakia and Poland also improved, but they ranked lower than in the intra-UE trade ranking. Slovakia ranked 17th, Poland - 14th (table 4).

**Table 4. V4 countries position in the ranking of EU countries arranged according to the values of high-tech export in extra-EU trade in 2007-2012**

Country	2007	2008	2009	2010	2011	2012
CZ	14	14	14	12	12	11
HU	10	9	9	9	9	10
PL	16	16	15	15	15	14
SK	20	23	22	21	21	17

source: own calculations based on Eurostat data (htec\_trd\_tot4)



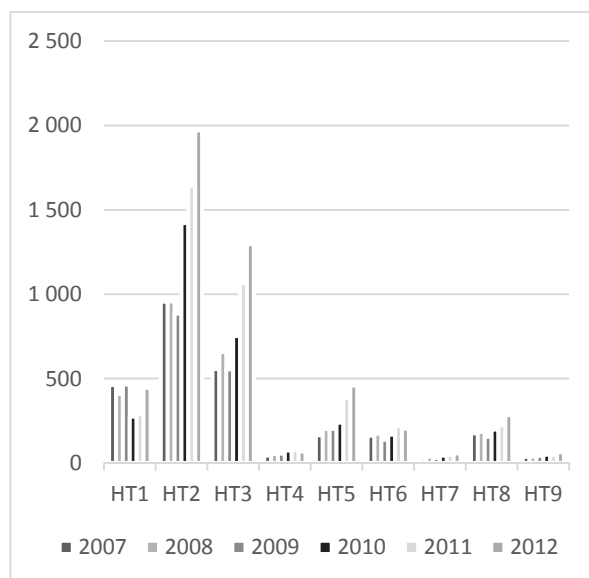
**Figure 3. Export of high-tech products from Czech Republic to EU countries in 2007-2012 in million euros**

Source: Eurostat (htec\_trd\_group4)

The groups of high-tech products the Czech Republic exported to EU countries included mainly computers-office machines (HT2) and electronics-telecommunications (HT3). The export of products from all remaining groups in 2012 accounted for less than 15% of the total value of export of HT2 and HT3 products (figure 3). Products exported to non-EU countries included the same groups of products (figure 4), but its value was definitely lower than in intra-EU trade. In 2012, the total value of trade in high-tech



sector amounted to EUR 4 849 million for extra-EU trade and EUR 14 858 million for intra-EU trade.



**Figure 4. Export of high-tech products from Czech Republic to non-EU countries in 2007-2012 in million euros**

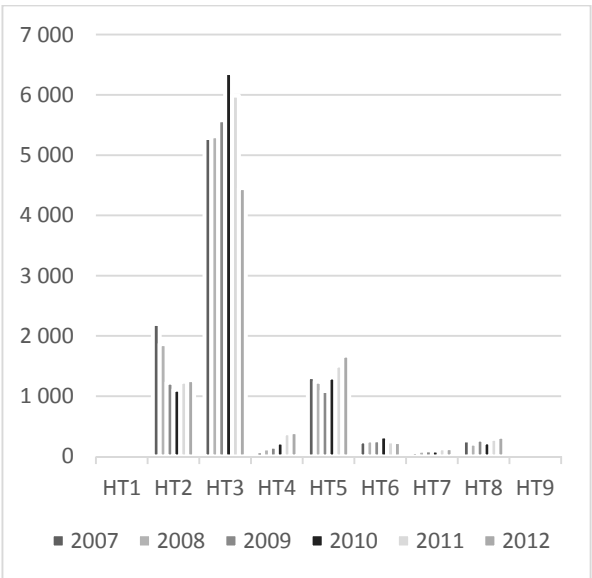
Source: Eurostat (htec\_trd\_group4)

The groups of high-tech products Hungary exported to EU countries included mainly electronics-telecommunications (HT3), computers-office machines (HT2) and scientific instruments (HT5). The export of products from all remaining groups in 2012 accounted for ca. 15% of the total value of export of the HT2, HT3 and HT5 products (figure 5). Groups of products exported to non-EU countries included electronics-telecommunications (HT3) and computers-office machines (HT2) (figure 6), and its value was approximately the same as that of intra-EU trade. In 2012, the total value of trade in high-tech sector amounted to 5 417 million EUR for extra-EU trade and 8 559 EUR million for intra-EU trade.

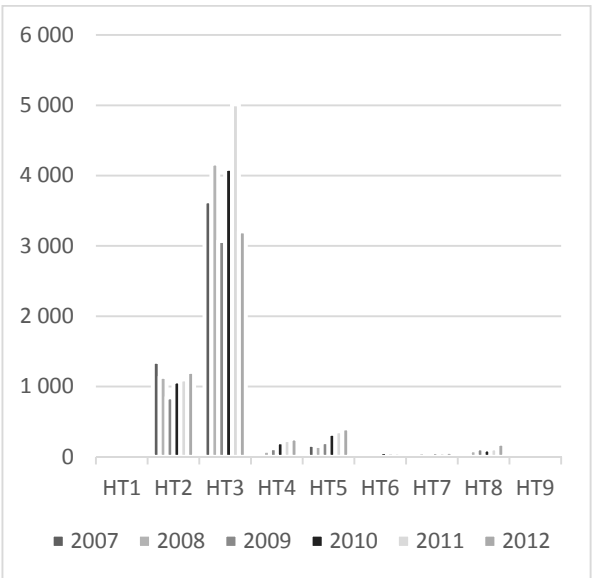
The groups of high-tech products Poland exported to EU countries included computers-office machines (HT2), and electronics-telecommunications (HT3). The export of products from all remaining groups in 2012 accounted for almost 30% of the total value of export of HT2 and HT3 products (figure 7). Groups of products exported to non-EU countries included aerospace (HT1), computers-office machines (HT2), and electronics-telecommunications (HT3) (figure 8), but its value was noticeably lower than that of intra-EU trade. In 2012, the total value of high-tech export amounted to 2 800 million EUR for extra-EU trade and 5 662 million EUR for intra-EU trade.

The groups of high-tech products Slovakia exported to EU countries included mainly electronics-telecommunications (HT3) and computers-office machines (HT2). The export of products from all remaining groups in 2012 accounted for ca. 12% of the total value of exports of HT2 and HT3 products (figure 9). The groups of products exported to non-EU countries included electronics-telecommunications (HT3) (figure

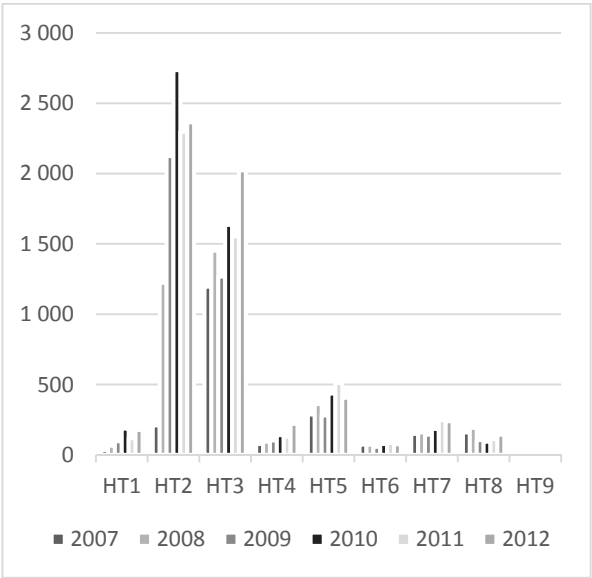
10), but its value was definitely lower than that of intra-EU trade. In 2012, the total value of export in high-tech sector amounted to 926 million EUR for extra-EU trade and 4 293 million EUR for intra-EU trade.



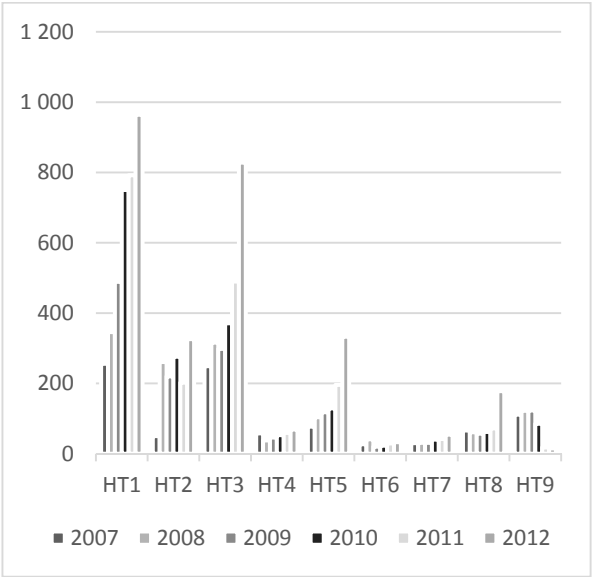
**Figure 5. Export of high-tech products from Hungary to EU countries in 2007-2012 in million euros**  
Source: Eurostat (htec\_trd\_group4)



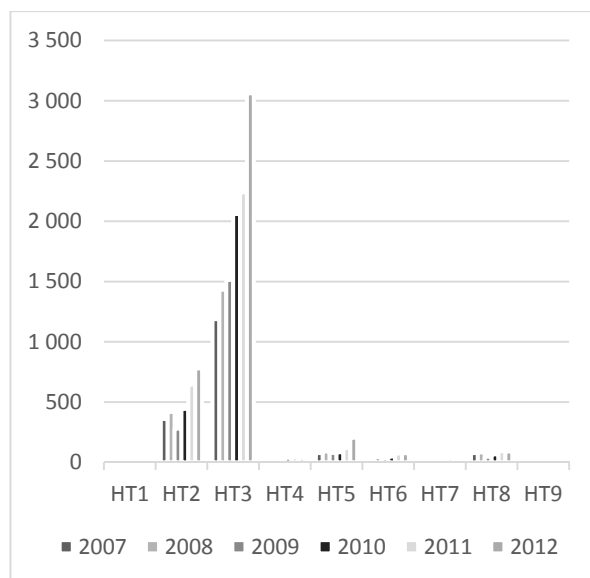
**Figure 6. Export of high-tech products from Hungary to non-EU countries in 2007-2012 in million euros**  
Source: Eurostat (htec\_trd\_group4)



**Figure 7. Export of high-tech products from Poland to EU countries in 2007-2012 in million euros**  
Source: Eurostat (htec\_trd\_group4)

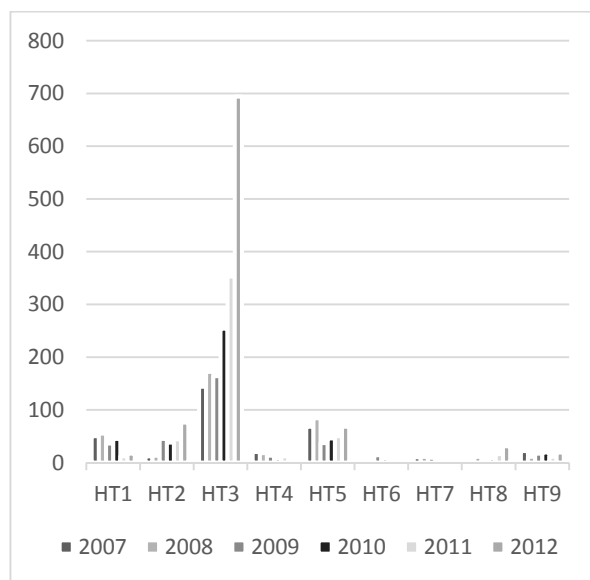


**Figure 8. Export of high-tech products from Poland to non-EU countries in 2007-2012 in million euros**  
Source: Eurostat (htec\_trd\_group4)



**Figure 9. Export of high-tech products from Slovakia to EU countries in 2007-2012 in million euros**

Source: Eurostat (htec\_trd\_group4)



**Figure 10. Export of high-tech products from Slovakia to non-EU countries in 2007-2012 in million euros**

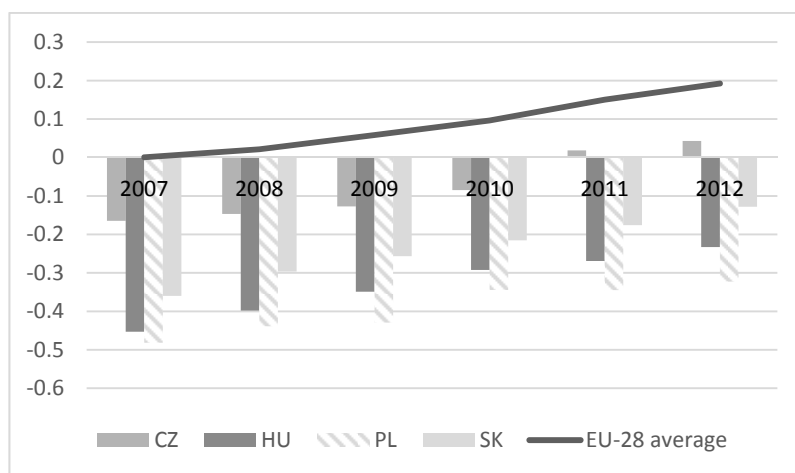
Source: Eurostat (htec\_trd\_group4)

If we compare the data for all the V4 countries, the highest total value of high-tech export can be noted in the Czech Republic, and the lowest in Slovakia. However, the highest value in extra-EU trade was achieved by Hungary. Interestingly, computers-

office machines (HT2) and electronics-telecommunications (HT3) had the highest share in high-tech export in all V4 countries. The remaining high-tech product groups constitute only a low percentage of the total value of high-tech export. Only Hungary exported more scientific instruments (HT5) than other V4 countries.

### Intellectual Capital Assets in V4 Countries

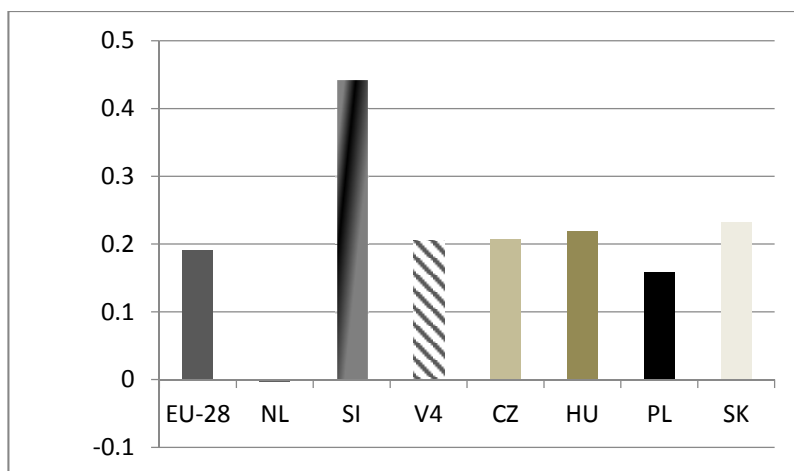
The average value of intellectual capital asset index (ICA) for EU countries in 2012 was 0.192. In the V4 countries, this value was much lower. From all of the V4 countries, the highest value of ICA was noted in the Czech Republic: 0.043 in 2012, followed by Slovakia: -0.128 in 2012, and Hungary: -0.233 in 2012. From all of the V4 countries, Poland had the lowest value of ICA: -0.322 in 2012 (figure 11).



**Figure 11. Value of synthetic intellectual capital assets index in V4 countries and EU-28 average in 2007-2012**

Source: own calculations based on Eurostat (edat\_lfse\_08, trng\_lfse\_01, rd\_p\_perslf, lfsi\_emp\_a, htec\_kia\_emp and htec\_kia\_emp2, isoc\_ci\_in\_h, isoc\_ci\_in\_e and isoc\_ci\_in\_en2, pat\_ep\_ntot, hrst\_fl\_tefor, isoc\_tc\_cal, tour\_occ\_arnat) and World Bank data (IP.JRN.ARTC.SC, IC.REG.DURS)

The ICA value gradually increased in all V4 countries. The average increase in the value of ICA from 2007 to 2012 was 0.192 for EU countries and 0.205 for V4 countries. From all of the EU countries, the highest increase in the ICA value was noted in Slovenia: from -0.255 to 0.188. In the Netherlands, the value of ICA dropped during the analyzed period from 0.661 to 0.657. From all of the V4 countries, the highest increase in the ICA value was noted in Slovakia, from -0.36 to -0.128, and the lowest was noted in Poland, from -0.481 to -0.322. In the Czech Republic and Hungary, the increase in the ICA value during the analyzed period was on a similar level: 0.209 in the Czech Republic and 0.22 in Hungary (figure 12).



**Figure 12. Value of change in synthetic intellectual capital assets index in V4 countries and EU-28 average in 2007-2012**

Source: own calculations based on Eurostat (edat\_lfse\_08, trng\_lfse\_01, rd\_p\_perslf, lfsi\_emp\_a, htec\_kia\_emp and htec\_kia\_emp2, isoc\_ci\_in\_h, isoc\_ci\_in\_e and isoc\_ci\_in\_en2, pat\_ep\_ntot, hrst\_fl\_tefor, isoc\_tc\_cal, tour\_occ\_arnat) and World Bank data (IP.JRN.ARTC.SC, IC.REG.DURS)

Despite of the big increase in the value of ICA during the analyzed period, the V4 countries ranked very low in the EU ranking. From all of the V4 countries, the Czech Republic achieved the highest position in the ranking in 2012: the 16th, followed by Slovakia: the 20th position, and Hungary: the 22nd position. From all of the V4, countries Poland ranked the lowest: 24th (table 5).

**Table 5. V4 countries position in the ranking of EU countries arranged according to the values of ICA in 2007-2012**

Country	2007	2008	2009	2010	2011	2012
CZ	16	17	17	17	16	16
HU	21	23	22	20	22	22
PL	23	24	24	23	24	24
SK	19	18	18	18	19	20

Source: own calculations based on Eurostat (edat\_lfse\_08, trng\_lfse\_01, rd\_p\_perslf, lfsi\_emp\_a, htec\_kia\_emp and htec\_kia\_emp2, isoc\_ci\_in\_h, isoc\_ci\_in\_e and isoc\_ci\_in\_en2, pat\_ep\_ntot, hrst\_fl\_tefor, isoc\_tc\_cal, tour\_occ\_arnat) and World Bank data (IP.JRN.ARTC.SC, IC.REG.DURS)

Poland noted the lowest value of the following indicators: HCA\_4 and RCA\_3, and the highest value of the SCA\_9 indicator, which was a destimulant. The SCA\_5 indicator had a definitely higher value in Poland than in other V4 countries. In the Czech Republic the following indicators: HCA\_1, HCA\_3, HCA\_5, RCA\_3, RCA\_5 noted the highest value compared to other V4 countries. In Slovakia, the HCA\_4, SCA\_1 and SCA\_2 indicators reached the highest value compared to other V4 countries. In Hungary, the value of the HCA\_6 and SCA\_3 indicators was higher than in other V4 countries; furthermore, Hungary noted the lowest value of the SCA\_9 indicator.

The results show a large variation of the ICA value in the V4 countries. Especially the Czech Republic noted a definitely higher value of ICA than other V4 countries, and

Poland can be distinguished by a much lower change of the ICA value during the analyzed period.

### Relation between Value of Exports in High-Tech Sector and Level of Intellectual Capital Assets

For estimated pooled models (Table 6), the value of adjusted  $R^2$  was no higher than 85%. ICA (X5) was a relevant variable (for  $\alpha=0.05$ ) in models for Y1 and Y2. In both cases, X5 had negative influence on high-tech export. This means that high-tech export to both EU and non-EU countries decreased as the value of ICA grew higher. After conducting tests (test for individual random effects, BP test, Hausman test), fixed effects models were estimated for all respective variables. The model for the Y2 variable had the highest value of adjusted  $R^2$  among estimated models. Total intramural R&D expenditure (X1), labour productivity (X3) and the gross value added (X4) were relevant variables (for  $\alpha=0.1$ ) in this model. All those variables had a positive influence on the value of high-tech export to non-UE countries.

The results may have different causes and require a deeper analysis. A part of high-tech products are manufactured by foreign subsidiary companies<sup>6</sup> and this is the cause why one country develops the idea and the design of a high-tech product and a different country manufactures it, which is why the low ICA value in the V4 countries was not an obstacle to exporting high-tech products.

**Table 6. The results of the estimation of panel models for V4 countries data**

Pooled models			FE models (relevant variables for $\alpha=0.1$ )		
variables	(Y1)	(Y2)	variables	(Y1)	(Y2)
(X1)	0.014***	0.017***	(X1)	0.006	0.007
(X2)	-0.21***	-0.55***	(X2)	0.115	-
(X3)	0.006	-0.03	(X3)	0.042	0.024
(X4)	1.911***	4.890***	(X4)	-	0.945
(X5)	-3.79***	-6.63***	(X5)	-	-
adjusted $R^2$	<b>0.84</b>	<b>0.85</b>	adjusted $R^2$	<b>0.96</b>	<b>0.98</b>

Significant codes: 0.01 '\*\*\*' 0.05 '\*\*' 0.1 '\*'

Source: own calculations based on Eurostat (htec\_trd\_tot4, lc\_lci\_r1\_cow, nama\_aux\_lp, nama\_r\_e3vab95r2, edat\_lfse\_08, trng\_lfse\_01, rd\_p\_perslf, lfsi\_emp\_a, htec\_kia\_emp and htec\_kia\_emp2, isoc\_ci\_in\_h, isoc\_ci\_in\_e and isoc\_ci\_in\_en2, pat\_ep\_ntot, hrst\_fl\_tefor, isoc\_tc\_cal, tour\_occ\_arnat) and World Bank data (IP.JRN.ARTC.SC, IC.REG.DURS)

For estimated pooled models (Table 7), the value of adjusted  $R^2$  was 91% for Y1, and 88% for Y2. ICA (X5) was an irrelevant variable (for  $\alpha=0.05$ ) in those models. Gross value added (X4) was the most relevant value for export to non-EU countries. After conducting tests, a fixed effects model was estimated for Y1, and a random effects model for Y2. The model for Y1 had the highest value of adjusted  $R^2$ . Labor productivity (X3) and the ICA (X5) were relevant variables in this model. Both variables had a

<sup>6</sup> According the results of A. Weresa (2002, p. 128) survey more than 58.6% (for high-technology) and 61.9% (for medium-high-technology) companies with foreign capital in Poland were innovative, and only than 49.2% (for high-technology) and 33.3% (for medium-high-technology) companies with Polish capital in Poland were innovative.

positive influence on high-tech export in intra-EU trade. Labor productivity (X3), gross value added (X4), and ICA (X5) were relevant variables. In this case, the variables had a positive influence on high-tech export in extra-EU trade as well.

**Table 7. The results of the estimation of panel models for EU countries data**

Pooled model			FE and RE models (relevant variables for $\alpha=0.1$ )		
variables	(Y1)	(Y2)	model	FE	RE
			variables	(Y1)	(Y2)
(X1)	-0.001	0.001	(X1)	-	-
(X2)	-0.001	0.006	(X2)	-	-
(X3)	0.007*	0.006	(X3)	0.023	0.017
(X4)	0.755***	0.692	(X4)	-	0.568
(X5)	0.698*	0.023	(X5)	0.786	0.626
adjusted R <sup>2</sup>	<b>0.91</b>	<b>0.88</b>	adjusted R <sup>2</sup>	<b>0.98</b>	<b>0.95</b>

Significant codes: 0.01 '\*\*\*' 0.05 '\*\*' 0.1 '\*'

Source: own calculations based on Eurostat (htec\_trd\_tot4, lc\_lci\_r1\_cow, nama\_aux\_lp, nama\_r\_e3vab95r2, edat\_lfse\_08, trng\_lfse\_01, rd\_p\_perslf, lfsi\_emp\_a, htec\_kia\_emp and htec\_kia\_emp2, isoc\_ci\_in\_h, isoc\_ci\_in\_e and isoc\_ci\_in\_en2, pat\_ep\_ntot, hrst\_fl\_tefor, isoc\_tc\_cal, tour\_occ\_arnat) and World Bank data (IP.JRN.ARTC.SC, IC.REG.DURS)

The results of the models for all EU countries show a different relation of high-tech export to intellectual capital assets than the models that only consider the V4 countries. For all of the V4 countries, ICA was not statistically significant in estimated FE models. In the case of data for all EU countries, ICA was statistically significant and had a positive impact on the level of high-tech export. Therefore, the findings of the analysis are not clear. On one hand, the Czech Republic, Hungary, Poland and Slovakia achieved fairly high positions in the rankings drawn by the level of high-tech export to the EU countries, on the other hand, the groups of high-tech products exported from the V4 countries were mainly computers-office machines, and electronics-telecommunications, whilst the V4 countries are often only the manufacturers of those products, and not their inventors and originators.

## CONCLUSIONS

The analysis creates an unclear picture of the situation. The value of high-tech export is not the same in all the V4 countries. From all of the V4 countries, the highest total value of high-tech export is noted in the Czech Republic, and the lowest in Slovakia. Hungary noted the highest value in the extra-EU trade in this sector. For all the V4 countries, the value of high-tech export in the intra-EU trade is higher than in the extra-EU trade. The adoption of the intellectual capital assets as a factor of export of high-tech products seemed to be a right choice because of the specific requirements of the sector. Econometric models estimated for the EU-28 confirmed that ICA has a significant and positive impact on the level of high-tech export. Models for the V4 countries showed the opposite situation – the value of ICA was not relevant to the level of high-tech export. M. Weresa (2012, p. 67) classified all of the V4 countries as belonging to a group of overtaking national innovation systems. M. Weresa emphasized (2012, p. 242) that international trade and foreign direct investment leads to transfer of



knowledge and increasing its resources in the country. The analysed period is too short to give definite results, because it takes decades for the level of knowledge, technology or intellectual capital of the countries to become even.

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