Braja, M., & Gemzik-Salwach, A. (2019). Competitiveness of high-tech sectors in the European Union: A comparative study. *Journal of International Studies, 12*(2), 213-227. doi:10.14254/2071-8330.2019/12-2/13

Journal of International Studies

Scientific Papers

Competitiveness of high-tech sectors in the European Union: A comparative study

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Abstract. In the 20th century the idea of competitiveness flourished and became one of the most popular buzzwords in economic debate, both among researchers and economic practitioners. Cutting-edge technologies and various innovations of today are perceived as the major factors of economic success, either on macro or microlevel. This paper aims at examining the relationship between R&D expenditures and export performance in high-tech sectors and the competitive advantages in these sectors in 16 European Union countries. In most of the analysed countries, the research found a dependence between the scale of R&D expenditures and the countries' export performance in the high-technology sectors. To achieve the predefined research objective, the authors used the correlation coefficients. The results of the study proved that R&D expenditures are strictly correlated with export performance of the examined countries. Moreover, the correlation between R&D expenditures and the Balassa RCA index confirms that the R&D expenditures in the high-tech are correlated with the competitive advantages in the Balassa meaning. The results of the performed analysis are largely consistent with theoretical and empirical literature economies' competitiveness and the impact of R&D expenditures and innovations.

Keywords: competitiveness, R&D expenditures, high-tech industries, pharmaceutical industry, electronic industry, Balassa index, Revealed Comparative Advantages.

JEL Classification: O14, O30, D89, F10

Received: November, 2018
1st Revision: February, 2019
Accepted: May, 2019

DOI: 10.14254/2071-8330.2019/12-2/13

1. INTRODUCTION

The role of competitiveness is well examined by both policymakers and scientists. Since the revolutionary Adam Smith's, The Wealth of Nations (Smith, 1776), followed by David Ricardo's Principles of Political Economy and Taxation (1817), many generations of economists were striving to find the factors which affected economic success of nations and economic entities. In the 20th century, the idea of competitiveness boomed and became one of the most popular buzzwords. Soon competitiveness was perceived as the primary cause and explanation for both successes and losses of economic entities. The competitiveness theory was being developed in different areas of economic sciences, i.e., microeconomic analysis, macroeconomics and the trade theory. As a result, there are hundreds of definitions for this notion, however, none of them were accepted as generic. In this context, the famous "Foreign Affairs" discussion between Krugman (1994), Clyde and Prestowitz (1994), Thurow (1994) and Cohen (1994) proved how the approach to competitiveness might vary.

Globalisation and liberalisation have reshaped the global economy and the way competitiveness is perceived. For over 30 years, this concept was evolving, became more complex, and hence, new factors were examined and marked as crucial for creating and maintaining competitive advantages. The interest of researchers and policymakers shifted from labour-force-driven competitiveness as presented in Hecksher's and Ohlin's theory to knowledge and innovation driven competitiveness, presented in later studies. The well-known Joseph Schumpeter's studies (Schumpeter, 1950) shifted economists' attention to the new fields not examined before: innovations, knowledge and technology. Next, Robert Solow, who defined technology as a continuous set of knowledge that became evident over time and not created by economic forces, built an endogenous growth model which consisted of capital accumulation, labour or population growth, and increases in productivity commonly referred to as technological progress (Cortright, 2001). The role of technology and innovations was well analysed, especially in the context of progressing trade liberalisation and globalisation.

To adjust to the observed changes in the global economy and industries, in 1984 the OECD adopted a new classification of manufacturing sectors: high technology sectors, medium-high technology sectors, medium-low technology sectors and low technology sectors. However, literature on the subject lacks a single, widely approved definition of what is high technology (Kiehl, 1988). Under the criteria adopted by the OECD these technologies include (Hatzichronoglou, 1996; Galindo-Rueda & Vender, 2016):

− production of basic pharmaceutical substances and medications, as well as other pharmaceutical products;

− production of computers, electronics and optical products;

− production of aircrafts, spaceships and similar machines.

The authors of this paper decided to analyse the relationship between R&D expenditures and competitiveness of the high-tech sectors for three reasons. The first reason is the lack of targeted research on the competitiveness of high-tech industries and the impact of R&D expenditures. The publications, with which the authors are familiar, usually discuss either the relationship between export performance and R&D expenditures, or the innovativeness. The second reason is the growing role of high-tech sectors countries' export performance. The third grounds for interest in this subject is the growing role of high-tech sectors for countries' export performance, supported by the concepts of Industry 4.0 and 'new economy'. As such, some researchers claim that the 'traditional' measures of competitive advantages are not relevant for the assessment of high-tech industry competitiveness (Ambroziak, 2017).

The first barrier in assessing the competitiveness of high-tech industries appears while defining high technologies in general. Since there is no general and approved definition of high technology (Kiehl, 1988; Zakrzewska-Bielawska, 2010), high-tech is usually defined through referring to core characteristics of this

vital branch in the economy. According to the Instituto Nacionalo de Estatistica, high technology is characterised by rapid adoption of knowledge, very superior to other technologies. High technologies, due to their degree of complexity, demand constant progress in research, as well as a robust technological base (INE, 2016). Relatively high investments in R&D activities, combined with high degrees of innovativeness are the key attributes distinguishing high-tech industries from others (Hatzichronoglou, 1996; Skórska, 2016). The high-tech industry is further characterised by high knowledge adoption (Zakrzewska-Bielawska, 2010) and by the demand for highly skilled employees (Grossmann, 1989; Machin & Van Rennen, 1998; Skórska, 2016). In high-tech industries, which tend to be very concentrated (Wang, 2009), the traditional factors of production (land, capital and labour) are replaced by knowledge and innovations. Contrary to the traditional factors endowment theory, the location of production, as well as exports and economic performance of high-tech industries is related to brainpower (Thurow, 1994) which can be sourced globally (Porter, 2000).

The statistics confirms that the role of high tech in the economy and in shaping its competitive advantages is growing (Zakrzewska-Bielawska, 2010). In 2017, 35 million persons were employed in high-tech manufacturing sector in the EU-28, representing 15.4% of the total employment. Research and development (R&D) spending in high-tech sectors of the EU-28 businesses increased by on average 4% per year during 2005-2014, reaching EUR 182 billion in 2014. High-tech products represented 17.0% of the value of all exports from the EU-28 back in 2014 (Eurostat 2018).

Technologies, knowledge and innovations play a vital role in economy: both short-term and long-term effects from their implementation are translated into economic growth and competitiveness of a country (Porter et al., 2001; Weresa, 2007; Kianto et al., 2013; Szarowska, 2017; Dobrovic et al, 2018). High-value-added and well-paid jobs can be easily translated into country's competitiveness (Tyson, 1992, Nadiri, 1993, Skawińska & Zalewski, 2014, WEF, 2017). In this context, technology and innovations are a tool used to gain and maintain competitive advantages of businesses, industries and countries as a whole (Roszko-Wójtowicz et al., 2018).

Knowledge-intensive and innovation-absorbing industries are perceived as primary drivers of economic growth and economy's competitiveness (Aiginger, 1998; Cortright & Meier, 2001; Lu & Yu, 2010; Simonen et al,. 2013; Skórska, 2016; Ungerman et al., 2018). Lu and Yu (2010) stressed on the role of high-tech industries in ensuring country's security. On the other hand, developed economies can create a favourable environment for further adoption of the newest technologies and serve as reservoirs for the most promising technologies (Ozawa, 1992; Gökmen & Turen, 2013; Skórska, 2016). As such, innovation-driven economies are perceived as the highest level of economic development (Porter, 1990; Ozawa, 1992).

This paper aims to examine the relationship between R&D expenditures, export performance in high-tech sectors and competitive advantages in high-tech sectors in 16 European Union countries. The following hypotheses were verified:

H1: R&D-related expenditures improve countries' export performance in high-technology sectors.

H2: R&D expenditures improve financial performance of high-tech enterprises.

H3. The higher is the level of R&D expenditures, the stronger would be countries' competitive advantages.

2. LITERATURE REVIEW

It is unequivocally confirmed that the export in the technologically advanced products is the most demanded way of competing in the international markets (Gökmen & Turen 2013, Maciejewski & Wach 2019). The relationship between the R&D intensity and the export performance is not a new research issue (i.e. Hirsch & Bijaoui 1985).

Bojnec and Ferto (2001) were examining the impact of R&D activity on export performance. They applied an adapted gravity model which combined the variables like market size (real GDP) of host 'i' and destination 'j' countries, geographical factors like the distance between capital cities (Distance) and common border (Contiguity), common cultural linkage (Language), and a dummy variable for Regional Free Trade Agreement (RFTA) membership as explanatory variables. Their studies confirmed that the R&D variable for exporting countries increased manufacturing exports. The OECD countries which invested more in R&D had higher manufacturing export.

Cortright and Meier (2001) analysed the high-tech specialisation on a municipal level using three factors: the employment patterns patent activity; and venture capital. Findings of their studies show that, despite similarities in industrial classification, occupational composition and research intensity, the high-tech industries are diverse and evolutionary. This diversity and the evolution of these sectors should be taken into account while analysing these sectors and creating the policies.

Braunerhjelm and Thulin (2006) tested the effect of the R&D on the export performance and determined one meaningful relationship: They estimated that one percentage point increase in R&D investments magnifies the share of high-technology export by approximately three percentage points. They examined the impact of the scale of the economy but determined no clear evidence of this factor. The research from Braunerhjelm and Thulin showed that traditional trade theory explanations fare much better the economic geography explanations - sizeable home markets - in determining the allocation of production and exports of high-technology products.

The research conducted by Skórska (2016), Dobrovic et al. (2018) and Ungerman et al. (2018) showed that the competitiveness of the high-tech industries diversifies the EU. The evidence showed that the Polish economy, in terms of high-tech and its competitiveness was lagging behind the Western European countries. Knowledge incorporated in new technologies, highly processed products, highly qualified labour resources that create and use these technologies, as well as products and services, determines the innovativeness of an economy and its international competitiveness.

Dumrul and Kılıçarslan (2018) analyzed for 16 OECD countries using data for the period 2000-2015. They examined if there is a long-term relationship between R&D expenditures and exports. The results showed that a 1% increase in R&D expenditure increased exports by 0.43-0.45%

Altay Topcu (2018) investigated the impact of R&D expenditures on high-tech manufacturing industry export from 24 OECD countries for the 1996-2015 period by using OLS, RE and FE Models. The obtained results showed that the significance of the R&D expenditures varied depending on the applied model. One of the models, FE Model, results showed that an increase in R&D expenditures by 1% point increased the high-technology manufacturing industry export by 2.27% point. The R2 value (0.815259) indicated that changes in R&D expenditures cause 81% of the changes in the high-tech manufacturing industry export.

The recent studies by Roszko-Wójtowicz et al. (2018) confirm that the R&D expenditures have a positive impact on the competitiveness of the industry, as well as on the economy itself. These results may also prove that that the role of R&D is increasing. A few years earlier Radosevic argued that the R&D system plays a relatively limited role in the current performance of the CEE economies (Radosevic 2004).

Ambroziak (2017) examined the case competitiveness of the NMS in the high-tech trade in the period 2007-2011. He applied four competitiveness indices: RCA, trade balance, trade coverage (TC) and share of high and medium-high technology products in the country export. The obtained results showed that all the NMS improved their competitive position in the high-tech products. However, the study confirmed that the traditional trade related indicators are not applicable to the high-tech product trade.

3. METHODOLOGY

In the research of the relations between the level of R&D expenditures and the competitiveness in the high tech sector 16 countries were examined: Czech Republic, Denmark, Germany, Estonia, Greece, Spain, France, Italy, Lithuania, Hungary, Netherlands, Poland, Portugal, Slovenia, Slovak Republic and the United Kingdom. The research period was 2008-2014. The analysis period began in 2008, which was the year of the outbreak of the last economic crisis. The crisis redefined relations in the global economy. Furthermore, since 2008, the rapid development of breakthrough technologies, such as blockchain, is observed. Under the conditions of dynamic changes in the business environment, the competitiveness of the high technology sector is a factor that can stabilize the economy and at the same time, be a catalyst for further positive changes. The final date of the research is 2014, which was selected due to the availability of data included in some international databases.

For the purpose of this study, we examined high-tech sectors according to the NACE Rev.2 classification, where high-technology includes the following manufacturing sectors:

- Manufacture of basic pharmaceutical products and pharmaceutical preparations (21);
- Manufacture of computer, electronic and optical products (26);
- Manufacture of air and spacecraft and related machinery (30.3)

This study is based on the data extracted from the World Bank database and from Eurostat. We treated these databases as the complimentary data source. Use of information provided by these two institutions gave us a complex set of data which were necessary for making the comprehensive analysis required to verify the predefined hypotheses.

In the first step, the correlation between the value of R&D expenditure and different measures of the competitiveness of high-tech sectors were calculated for each analysed country. During the selection of the competitiveness measures we used two-stage approach. First, we selected the methods related to the high technology sectors as a whole (high-technology manufacturing and knowledge-intensive high-technology services). Next, by analogy, we determined the same measures only for the high technology manufacturing sector. In the first stage of the research the following measures of the competitiveness were analysed:

- export in the high technology sector, both expressed as a share in the manufacturing; as well as in the USD;
- number of enterprises in the high-tech sector.

In the next stage, we used the financial data from the financial statements of the enterprises active in the area of the high technologies, such as: the turnover, production value, created value added, operational profit and purchase of goods and services.

Then, the test of statistical significance at 0.1 significance level was conducted for each single case. It means that, for each correlation coefficient, we made the assumption that the calculated value of the correlation coefficient is significantly different from 0 and in 90% is not a result of a coincidence. The verification of the hypothesis was made on the basis of the statistics, which with the assumption of the hypothesis true, has a t-Student dispersion with n-2 levels of freedom. Later, the estimated values were compared with the critical values presented in the tables for the 0.1 level of significance and the

predefined number of levels of freedom. Whenever the estimated value Tn-2 did not fit the critical set it meant that the calculated correlation coefficient should be accepted as the significant one.

In the third stage of the research, we calculated the Balassa index of Revealed Comparative Advantages (RCA). For most studies in the field of competitiveness, competitiveness is equated with the comparative advantages possessed by the entity (Traill & da Silva, 1996). Therefore, they are measures of "ex post" competitiveness - analogically - indicators of comparative advantages. The basic indicator used in research advantages the indicator of disclosed comparative benefits is comparative (RCA). It was developed in 1965 by Bela Balassa, who sought to show the causes of international specialization. In the original version this is expressed by the following formula (Balassa, 1965):

$$RCA_i = \frac{X_{ik}}{X_{iw}} / \frac{X_k}{X_w}$$

where:
Xik-export of i-th product from country k
Xiw-export of i-th product in world export
Xk-export of the country k
Xw-global exports

At the end, the authors calculated the correlation between the R&D expenditures and the Balassa RCA index. This step let us test the 3rd hypothesis.

4. EMPIRICAL RESULTS AND DISCUSSION

The conducted research proved that the relationship between the scale of R&D expenditures and various measures of the competitiveness differ among the analysed countries.

The calculated correlation coefficients were presented in Table 1. The value of the tested statistics was presented in the brackets. The critical values were quoted according to the distribution table of the t-Student statistics, and their value is 0.67. The values of the correlation coefficients with the positive significance tests were marked bold.

In most of the analysed cases, the value of Tn-2 statistics did not fall into the critical series, which means no reason for the refusal of the hypothesis on the correlation between the values. The values for which the significance test of the correlation coefficient was positive and for which the correlation coefficient was either higher than 0.7 or lower than -0.7, were marked grey. These values are statistically significant, and the relationship between the analysed variables is high, very high or even total.

In most of the analysed cases, the research proved that there is a relationship between the scale of the R&D expenditures and the export. As such, the results of the study are in line with the previous studies (In 7 out of 16 cases the relationship between the R&D expenditures and export expressed in the % of manufacturing, the relation was positive and high or very high. Regarding the export expressed in USD, the positive and high correlation was determined in 8 cases. In five analysed countries export (expressed in % of manufacturing and the USD) was positively correlated with the R&D expenditures. It means that in these countries, the growth in the R&D related expenditures is linked with the higher exports in the high-tech sectors. However, in four cases, these correlations did not occur together. This situation requires a more in-depth analysis and will be further examined in the subsequent studies.

Table 1

The correlation coefficients between the R&D expenditures and the measures of the competitiveness in the high-tech sectors and values of test statistics for the calculated correlation coefficients

	R&D expenditures vs export in the high tech sectors as a % of manufacturing	R&D expenditures vs export in the high-tech sector in USD	R&D expenditures vs number of the enterprises in the high-tech sectors
Czech Republic	-0.16 (-0.35)	**0.75 (2.55)**	**0.29 (0.69)**
Denmark	**-0.38 (-0.91)**	**-0.57 (-1.56)**	**0.95 (7.05)**
Germany	**0.32 (0.75)**	**0.58 (1.59)**	**0.93 (5.77)**
Estonia	**0.71 (2.27)**	**0.83 (3.29)**	**0.68 (2.07)**
Greece	**0.43 (1.08)**	0.29 (0.67)	**0.46 (1.17)**
Spain	**-0.82 (-3.26)**	**-0.82 (-3.15)**	**-0.96 (-7.98)**
France	**0.75 (2.57)**	**0.56 (1.50)**	**0.97 (9.41)**
Italy	0.19 (0.44)	0.09 (0.21)	**-0.83 (-3.37)**
Lithuania	**0.47 (1.20)**	**0.91 (4.77)**	**0.89 (4.46)**
Hungary	**-0.91 (-4.91)**	**-0.79 (-2.90)**	-0.16 (-0.35)
Netherlands	**-0.72 (-2.29)**	0.20 (0.45)	**0.94 (6.16)**
Poland	**0.83 (3.27)**	**0.93 (5.59)**	**0.97 (8.90)**
Portugal	-0.03 (-0.07)	-0.18 (-0.40)	**0.43 (1.06)**
Slovenia	0.03 (0.08)	0.20 (0.46)	**0.86 (3.85)**
Slovak Republic	**0.91 (4.81)**	**0.86 (3.81)**	**0.92 (5.36)**
United Kingdom	0.27 (0.62)	**0.64 (1.81)**	**0.95 (6.55)**

Source: own research

Regarding the relationship between the R&D expenditures and a number of enterprises operating in the high-tech, in 11 countries, the relationship between these two values was either very high or high. The relationship between the R&D expenditures and the number of companies operating in the high-tech was statistically meaningful and positively correlated in 13 countries. In these countries, the growth in the R&D expenditures was strictly related to the number of high-tech companies. For nine countries, this relationship was strong or even very strong.

The two countries in which the most significant positive relationship between the R&D and other measures of the high-tech competitiveness were identified are Poland and Slovakia. In these two countries the relationship between the value of the R&D expenditures and the three preselected measures of the high-tech competitiveness was positive and either high or very high. These two countries were followed by Lithuania, where a strong correlation between the R&D expenditures and two measures of high-tech competitiveness were identified. The next countries were Estonia and France with a very high or even full correlation between the R&D and the competitiveness in the high-tech sectors. This lets the authors conclude that the efficiency of the R&D spending in those countries was high or even very high. On the other hand, it may confirm that the R&D expenditures are targeted on the high-tech sectors.

In some cases, the correlation between R&D expenditures and high-tech competitiveness was negative. These cases require a thorough analysis. Spain is one of such countries: the relationship between the R&D expenditures and the export value is at the same time negative and very strong, and the relationship between the R&D expenditures and the number of the enterprises operating in the high-tech sectors is negative and almost full. The obtained results might prove that the R&D expenditures are not targeted on the high-tech sectors. These results are in line with the studies conducted by Caldera (2010)

show that the intra-EU market with a relatively high level of product quality and standards, this result indicates that product differentiation seems to be a superior strategy for entering the foreign market than cost-reducing innovation. During the investigation period, Spanish firms had to undergo product upgrading to meet the rapidly evolving standards of the EU.

Hungary is another country with a similar situation. The decrease in high-tech exports accompanies the growth in R&D expenditures. Regarding the correlation between the R&D expenditures and the number of enterprises in the high-tech, the obtained result was not significant statistically.

In the case of Denmark, the relationship between the R&D expenditures and the export is statistically significant, negative and weak to medium. At the same time, the relationship between the R&D expenditures is statistically meaningful, positive and almost total. This may suggest that the R&D expenditures in Denmark are equally dispersed among the Danish enterprises and that most of the R&D spend in Denmark is related to the emerging innovations, not exported yet. These conclusions, in general, are compliant with the previous studies of the Danish economy which show that the R&D expenditure and export of Denmarkis related to each other (Smith et al., 2002).

In the next stage of the study, the analogous calculations were conducted for the relations between the R&D expenditures and financial data for the companies operating in the high-tech sectors. The obtained results were presented in Table 2.

Table 2

The correlation coefficients between the R&D expenditures and the financial performance of the companies operating in the high-tech sectors

	R&D expenditures vs. turnover or gross premiums written	R&D expenditures vs. production value	R&D expenditures vs. value added at factor cost	R&D expenditures vs. gross operating surplus	R&D expenditures vs. total purchases of goods and services
Czech Republic	0.22 (0.50)	0.09 (0.20)	0.16 (0.36)	**-0.46 (-1.17)**	0.13 (0.30)
Denmark	**0.91 (5.02)**	**0.88 (4.17)**	**0.91 (5.01)**	**0.90 (4.53)**	**0.86 (3.79)**
Germany	**0.79 (2.85)**	**0.85 (3.54)**	**0.90 (4.73)**	**0.82 (3.18)**	**0.46 (1.16)**
Estonia	**0.81 (3.13)**	**0.83 (3.29)**	**0.65 (1.89)**	**0.80 (3.02)**	**0.81 (3.13)**
Greece	**0.55 (1.46)**	**0.54 (1.45)**	**0.53 (1.40)**	**0.61 (1.17)**	0.16 (0.36)
Spain	**0.92 (5.22)**	**0.90 (4.58)**	**0.95 (7.20)**	**0.79 (2.83)**	**0.90 (4.56)**
France	**0.71 (2.28)**	**0.88 (4.18)**	**0.82 (3.23)**	**-0.49 (-1.26)**	**0.75 (2.54)**
Italy	**-0.81(-3.09)**	**-0.67 (-2.03)**	**-0.57 (-1.53)**	**-0.63 (-1.83)**	**-0.66 (-1.99)**
Lithuania	**0.81 (3.11)**	**0.54 (1.45)**	**0.97 (8.29)**	**0.74 (2.49)**	0.24 (0.56)
Hungary	**-0.83 (-3.29)**	**-0.79 (-2.91)**	**0.62 (1.75)**	**0.29 (0.69)**	**-0.86 (-3.78)**
Netherlands	**0.68 (2.06)**	**0.65 (1.93)**	**0.78 (2.75)**	**0.49 (1.24)**	**0.59 (1.65)**
Poland	**0.77 (2.71)**	**0.77 (2.69)**	**0.75 (2.54)**	**0.52 (1.35)**	**0.74 (2.48)**
Portugal	**0.85 (3.60)**	**0.89 (4.25)**	**0.91 (5.00)**	**0.84 (3.49)**	**0.83 (3.34)**
Slovenia	**0.72 (2.34)**	**0.82 (3.17)**	**0.67 (2.00)**	**0.49 (1.25)**	**0.79 (2.86)**
Slovak Republic	**0.79 (2.91)**	**0.59 (1.65)**	**0.62 (1.77)**	-0.02 (-0.05)	**0.40 (0.98) export decrease**
United Kingdom	**0.93 (5.49)**	**0.94 (6.43)**	**0.96 (7.43)**	**0.91 (5.05)**	**0.87 (3.95)**

Source: own calculation

Regarding the relations between the R&D expenditures and the financial performance of the companies operating in the high-tech sectors, the correlation was visible. Out of 80 analyzed cases of the correlation between the R&D expenditures and the financial conditions, only 7 were statistically not significant. In most cases, the relationship between the R&D expenditures and the financial results of

high-tech companies was strong, very strong or even total. The obtained results confirm that the R&D expenditures can be translated into the good financial performance of the high-tech companies.

The group in which the relationship between the R&D expenditures and the financial performance was at the same time positive and high are Denmark, Estonia, Spain and Portugal. For those countries, the correlation between R&D expenditures and the financial performance was statistically significant. Moreover, it was positive and either high, very high or almost total.

In the first part of this study the results showed that in Denmark the correlation between the R&D expenditures and the export performance in the high-tech sectors was negative. However, the correlation between the number of the enterprises and the R&D expenditures was positive and almost ideal. This leads us to the conclusion that the R&D expenditures in Denmark positively create the competitiveness of the Danish economy, but the R&D expenditures are not necessary for the Danish export.

On the other hand, for Spain, for which there were negative correlations in the previous study (increase in R&D spending is accompanied by a drop in high technology exports and a decrease in the number of enterprises operating in this sector), all significant positive correlations were obtained in the analysis of the financial results of enterprises R&D expenditure is accompanied by improved financial performance of enterprises). The correlations between expenses on R&D and gross operating surplus can be described as high.

The next group of countries included Denmark, Estonia, France and Poland - four important, positive and high, very high or almost full correlations between R&D expenditure and the results of high technology enterprises. It is worth noting that this is the same group of countries for which in the previous study a large relationship between R&D expenditure and the competitiveness of the high technology sector was found.

Countries for which there was no positive relation between R&D expenditure and financial results of high-tech enterprises are Italy and Hungary. Especially in Italy, we can talk about a large, negative correlation of the surveyed volumes, that is, despite the increase in expenditure on R&D, the financial results of enterprises from the high-tech sector are deteriorating.

In order to more accurately explore these issues, an additional analysis of the relationship between R&D expenditures and financial results was carried out, but now companies from only the high-technology manufacturing sector were taken into account. Previously, financial data from the entire high-technology sectors was used, which consists of sectors: high-technology manufacturing and knowledge-intensive high-technology services. The results of the calculation are presented in Table 3.

The relationship between R&D expenditures and financial data of enterprises operating in the high-technology manufacturing sector is not as strong as in the previous analyzed case. This is probably due to the fact that R&D spending is more focused on the knowledge-intensive high-technology services sector than on the high-technology manufacturing sector. The table above points out that the correlation coefficients for R&D and turnover or gross premiums written are almost identical to the correlation coefficients of R&D expenditure and production value. This is due to the fact that only data on turnover or gross premiums written and production value are already available.

To better determine the competitiveness of the high technology sector in the countries studied, an indicator of the disclosed comparative advantage, called the Ballasa index of Revealed Comparative Advantages, was additionally used. In order to determine exactly which part of the high technology sector is characterized by a comparative advantage, a measure was calculated separately for the electron sector separately for the pharma sector. The results of the calculations are presented in Tables 4 and 5. The tables give the results in bold greater than one, which mean the comparative advantage of the country in the trade of the goods.

If the value of the RCA is higher than 1, we might assume that the country has the competitive advantages in the Balassa context. Our research proved that, in the examined period, the highest values of the RCA index in the electro sector were estimated for the Netherlands. Among the countries which had the RCA values above 2 were the economic engines of the EU: Germany, Denmark, France and the United Kingdom. It is worth mentioning that the RCA in the electronic trade in Estonia has improved radically in the examined period. Slovakia, Czech Republic and Hungary were the leaders in the group of the "new" member states with the RCA values higher than 1.5 in the whole research period. These results are compliant with the research conducted by Wysokińska (2008). The greater than 1 level of the disclosed comparative advantage indicator for the group of goods based on investments with a relatively high share of capital – intensiveness was achieved during development by such countries as Slovakia, Slovenia, Poland, and the Czech Republic, which to a great extent was preconditioned by the inflow of foreign direct investment to those countries, but also growing outlay on domestic investment, especially following accession to the European Union (Wysokińska 2008). A >1 level of the RCA indicator demonstrating a comparative advantage in the technology–based group of goods was only achieved by Slovenia, Poland, the Czech Republic, and Hungary over the final years of the examined decade (Wysokińska, 2008).

Table 3

Correlation coefficients between expenditures on R&D and financial results of enterprises operating in the high-technology manufacturing sector and the value of test statistics for calculated correlation coefficients

	R&D expenditures vs. turnover or gross premiums written	R&D expenditures vs. production value	R&D expenditures vs. value added at factor cost	R&D expenditures vs. gross operating surplus	R&D expenditures vs. total purchases of goods and services
Czech Republic	**0.35 (0.84)**	**0.33 (0.79)**	**0.86 (3.72)**	**0.89 (4.36)**	0.07 (0.15)
Denmark	**0.93 (45.72)**	**0.93 (5.45)**	**0.93 (5.75)**	**0.92 (5.22)**	**0.91 (5.07)**
Germany	0.28 (0.66)	**0.43 (1.06)**	**0.62 (1.75)**	**0.39 (0.94)**	0.11 (0.26)
Estonia	**0.87 (3.91)**	**0.87 (3.98)**	**0.88 (4.07)**	**0.89 (4.33)**	**0.84 (3.51)**
Greece	**0.59 (1.62)**	**0.61 (1.72)**	**0.50 (1.30)**	**0.53 (1.41)**	**0.57 (1.56)**
Spain	**0.86 (3.74)**	**0.78 (2.75)**	0.23 (0.54)	**-0.26 (-0.59)**	**0.90 (4.49)**
France	**-0.45 (-1.12)**	0.02 (0.05)	0.14 (0.31)	**-0.34 (-0.82)**	**-0.41 (-0.99)**
Italy	**-0.68 (-2.07)**	**-0.57 (-1.57)**	-0.04 (-0.09)	**0.23 (0.53)**	**-0.66 (-1.97)**
Lithuania	**0.74 (2.47)**	**0.72 (2.34)**	**0.84 (3.43)**	**0.76 (2.60)**	**0.52 (1.37)**
Hungary	**-0.77 (-2.71)**	**-0.82 (-3.20)**	**0.34 (0.81)**	**0.54 (1.45)**	**-0.79 (-2.920**
Netherlands	**0.60 (1.68)**	**0.64 (1.86)**	**0.46 (1.17)**	**0.40 (0.97)**	**0.54 (1.43)**
Poland	0.23 (0.54)	**0.33 (0.79)**	**-0.38 (-0.93)**	**-0.37 (-0.90)**	**0.31 (0.72)**
Portugal	**0.44 (1.09)**	**0.55 (1.48)**	0.09 (0.21)	-0.18 (-0.40)	**0.49 (1.27)**
Slovenia	**0.82 (3.20)**	**0.83 (3.33)**	**0.49 (1.27)**	**0.36 (0.86)**	**0.89 (4.42)**
Slovak Republic	**-0.52 (-1.35)**	**-0.50 (-1.28)**	-0.19 (`-0.44)	-0.15 (-0.35)	**-0.65 (-1.90)**
United Kingdom	-0.24 (-0.54)	-0.23 (-0.52)	**-0.40 (-0.98)**	**-0.53 (-1.39)**	**0.32 (0.75)**

Source: own calculation

Table 4

Index of Revealed Comparative Advantages of the EU Electro (NACE 26) sector in 2008-2014

	2008	2009	2010	2011	2012	2013	2014
Czech Republic	**1.81**	**1.76**	**1.87**	**2.03**	**1.97**	**1.88**	**1.85**
Denmark	**2.26**	**2.17**	**2.31**	**2.45**	**2.47**	**2.37**	**2.52**
Germany	**2.88**	**2.76**	**2.87**	**2.92**	**2.94**	**3.04**	**3.00**
Estonia	0.80	0.68	**1.07**	**1.67**	**1.66**	**1.83**	**1.93**
Greece	0.96	0.83	0.78	0.91	0.82	0.77	1.17
Spain	1.07	0.95	0.96	0.84	0.74	0.71	0.75
France	**2.20**	**2.13**	**2.24**	**2.36**	**2.37**	**2.48**	**2.39**
Italy	**1.06**	**1.09**	**1.14**	**1.26**	**1.21**	**1.24**	**1.15**
Lithuania	0.54	0.38	0.42	0.41	0.40	0.44	0.51
Hungary	**2.79**	**3.09**	**3.12**	**2.95**	**2.51**	**2.33**	**1.96**
Netherlands	**12.09**	**12.09**	**12.21**	**12.34**	**12.50**	**12.69**	**13.01**
Poland	0.87	**1.09**	**1.12**	0.94	0.97	0.97	**1.10**
Portugal	**2.57**	**1.63**	**1.57**	**1.70**	**1.56**	**1.46**	**1.39**
Slovenia	0.37	0.43	0.52	0.57	0.44	0.48	0.50
Slovak Republic	**2.06**	**2.38**	**2.22**	**2.08**	**2.19**	**2.41**	**2.35**
United Kingdom	**2.91**	**3.19**	**2.92**	**2.73**	**2.77**	**2.61**	**2.73**

Source: own calculation

In the next step, the RCA index for the pharmacy industry was calculated. In the pharma sector, however, the countries in Denmark are Denmark, in selected years, France, Slovenia and United Kingdom. Contrary to the previous industry, the RCA values were significantly lower than in the electronics sector. The RCA values exceeded 1 only in 4 analyzed countries: Slovenia, Denmark, France and the United Kingdom.

This may let us assume that these four countries gained and are able to maintain the competitive advantages in this sector. To some extent, it might be a result of the presence of the important global pharma players, such as: KRKA (Slovenia), Novo Nordisk and Pharma Nord (Denmark), Sanofi. Omega Pharma, Aventis, Synthélabo, Theo (France), or GlaxoSmithKline, Pfizer (the United Kingdom).

Table 5

Index of Revealed Comaprative Advantages of the EU Pharma (NACE 21) sector in 2008-2014

	2008	2009	2010	2011	2012	2013	2014
Czech Republic	0.20	0.20	0.21	0.21	0.19	0.21	0.26
Denmark	**1.37**	**1.30**	0.89	0.98	0.94	**1.05**	**1.03**
Germany	0.96	0.90	0.87	0.87	0.88	0.91	0.90
Estonia	0.09	0.08	0.08	0.06	0.06	0.07	0.07
Greece	0.83	0.81	0.81	0.68	0.60	0.68	0.65
Spain	0.84	0.76	0.79	0.83	0.80	0.77	0.71
France	**1.12**	**1.10**	**1.12**	**1.05**	**1.09**	**1.15**	**1.05**
Italy	0.65	0.64	0.68	0.74	0.75	0.87	0.87
Lithuania	0.17	0.25	0.24	0.25	0.24	0.27	0.34
Hungary	0.53	0.51	0.59	0.73	0.74	0.74	0.69
Netherlands	0.43	0.46	0.50	0.52	0.68	0.71	0.78
Poland	0.20	0.19	0.23	0.22	0.23	0.26	0.28
Portugal	0.24	0.25	0.24	0.30	0.28	0.27	0.31
Slovenia	**1.35**	**1.27**	**1.28**	**1.40**	**1.43**	**1.57**	**1.47**
Slovak Republic	0.11	0.11	0.12	0.12	0.09	0.10	0.12
United Kingdom	**1.38**	**1.42**	**1.40**	**1.32**	**1.34**	**1.08**	**1.16**

Source: own calculation

In order to check how much the results of calculations achieved are related to expenditure on R&D, correlations between the amount of expenditure on R&D and the Balassa RCA index for both sectors were also calculated. The results are presented in Table 6.

In the tests as the previously calculated value of the test statistic for the correlation coefficients and they were written in brackets. Values of correlation coefficients for which the materiality test was successful were bolded. In addition, the gray color is indicated in the table of quantities for which the materiality test was successful and for which it can be assumed that the relationship between the analyzed variables is high, very high or almost full.

Table 6

Interdependence between R&D expenditure and the balance measure for the electro and pharmaceutical sectors as well as the values of testing statistics for calculated price lists

	R&D expenditures vs. Values of Balassa RCA index for the electric industry	R&D expenditures vs. Values of Balassa RCA index for the pharma industry
Czech Republic	**0.48 (1.24)**	**0.47 (1.18)**
Denmark	**0.77 (2.70)**	**-0.62 (-1.79)**
Germany	**0.85 (3.60)**	**-0.34 (-0.80)**
Estonia	**0.81 (3.13)**	**-0.91 (-4.95)**
Greece	**0.45 (1.12)**	**0.47 (1.19)**
Spain	**0.92 (5.19)**	**0.64 (1.85)**
France	**0.89 (4.29)**	**-0.31 (-0.73)**
Italy	**0.52 (1.35)**	**0.96 (7.42)**
Lithuania	**0.40 (0.97)**	**0.71 (2.25)**
Hungary	**-0.88 (-4.17)**	**0.80 (2.98)**
Netherlands	**0.93 (5.73)**	**0.93 (5.65)**
Poland	0.14 (0.31)	**0.91 (4.78)**
Portugal	**0.34 (0.82)**	**-0.66 (-1.94)**
Slovenia	**0.59 (1.63)**	**0.78 (2.80)**
Slovak Republic	**0.37 (0.90)**	-0.23 (0.52)
United Kingdom	**-0.70(-2.17)**	**-0.76 (-2.62)**

Source: own calculation

The obtained results confirmed the existence of a relationship between R&D expenditures and the competitiveness of a given country measured by the Balassa index. Out of 32 obtained results, only in 2 cases we can talk about the lack of significance of correlation, and in 12 cases the correlation came out significant, positive, high, very high or almost full. The results that meet these conditions are 6 for the electro and 6 for the pharma sector.

5. CONCLUSION

This paper aimed at examining the relationship between the R&D expenditures, the export performance in the high-tech sectors and the competitive advantages in the high-tech sectors in 16 European Union countries. Three hypotheses were verified positively:

In most of the analysed countries the research proved that there is a dependence between the scale of the R&D expenditures and the countries' export performance in the high technology sectors. As such, the H1 hypothesis was confirmed.

Moreover, the R&D results were related with the financial performance of the companies in the analysed high-tech industries.

The correlation between the R&D related expenditures and the Balassa RCA index confirms that there is a relationship between the R&D expenditures in the high-tech sectors and the competitive advantages in the Balassa meaning.

The results of the performed analysis are largely consistent with the theoretical and empirical literature related to the competitiveness of the economies, role of the R&D expenditures and innovations. The findings of this study prove that the countries should produce and export advanced technology products that create high added value for achieving sustainable economic growth. As a result, it can be said that the share of R&D expenditure should increase and a concerted effort should be made to train a highly skilled and qualified workforce for increasing advanced technology products.

6. LIMITATION

Although Authors achieved the research objectives, the research timeframe and the scope of analysis caused some limitations. Being convinced that the competitive high-tech sectors can serve as the safety nets in times of economic contraction, Authors analysed the changes in the high-tech competitive position after the financial crisis. Thus, the research concentrated on the years 2008-2014. The selected research period was long enough for determining the rate of economic recovery observed after years 2008-2014. The final date of the research is 2014, which was chosen due to the availability of data included in some international databases. Hence, the Authors will continue the studies of this problem and the analysis presented in this particular paper will be extended to other countries. Also, other measures of the competitive position will be examined in the following research.

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