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Management of the process of formation and realization of competitive advantages of the Visegrad Four countries in the European market of ICT services

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Purpose – to assess the integration and management of the formation and implementation of the competitive advantages of the Visegrad Four countries in the European market of information, computer, telecommunication (ICT) services based on their analysis in the individual market segments.

Design/Method/Research approach - this study aims to determine the presence and nature of the competitive advantages of countries in the European ICT services market based on the calculation of export specialization indicators, to establish factors for their growth and effective implementation based on the results of structural, regressive, comparative analysis and synthesis .

Findings. It has been suggested that the introduction of the European rules for market organization stimulated the building-up in the Visegrad Four countries of their competitive advantages in the European ICT services market through innovative investment resources, effective management of private, public sector and international investors and personnel.

Practical implications. The accession of Eastern European countries to the European digital market and digital space requires a generalization of the experience of the Visegrad four countries and the identification of factors, directions and priorities of the national policy for the development of the ICT sector.

Originality/Value. Scientific novelty of the study - based on the calculation of the comparative advantage index, different integration and effectiveness of managing the competitive advantages of the Visegrad Four countries, primarily the sphere of IC services to the European market (relatively high - in the Czech Republic due to state financing, moderate – in Poland due to financial support from the state, in Slovakia due to private investment in R&D, low – in Hungary), this situation requires a balanced innovation and investment strategy of the countries in the future, the training of a sufficient number of qualified IT specialists, stimulation of private investment in R&D and business cooperation with the sphere of knowledge by means of tax and administrative incentives, facilitating the transition of small and medium-sized businesses on the principles of economics 4.0.

Paper type – empirical.

Keywords: export specialization; European market; ICT services; national strategies; innovation and investment factors.

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Управління процесом формування та реалізації конкурентних переваг країн Вишеградської четвірки на європейському ринку ІКТ послуг

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Мета роботи – дати оцінку інтегрованості та управлінню процесом формування та реалізації конкурентних переваг країн Вишеградської четвірки на європейському ринку інформаційних, комп'ютерних, телекомунікаційних (ІКТ) послуг на основі їх аналізу та в окремих сегментах ринку.

Дизайн/Метод/План дослідження. Це дослідження націлене на те, щоб визначити наявність та характер конкурентних переваг країн на європейському ринку ІКТ послуг на основі розрахунку показників експортної спеціалізації, встановити чинники їх нарощування та ефективної реалізації за результатами структурного, регресійного, компаративного аналізу та синтезу.

Результати дослідження. Зроблено припущення, що запровадження європейських правил організації ринку стимулювало нарощування в країнах Вишеградської четвірки їх конкурентних переваг на європейському ринку ІКТ послуг за рахунок інноваційно-інвестиційних ресурсів, ефективного управління коштами приватного, державного секторів і коштами міжнародних інвесторів та забезпечення персоналом.

Практичне значення дослідження. Приєднання країн Східної Європи до європейського цифрового ринку та цифрового простору потребує узагальнення досвіду країн Вишеградської четвірки й визначення чинників, напрямів та пріоритетних завдань національної політики розвитку ІКТ сектору.

Оригінальність/цінність/ наукова новизна дослідження – на основі розрахунку індексу порівняльних переваг встановлена різна інтегрованість та результативність управління конкурентними перевагами країн Вишеградської четвірки, першочергово, сфери ІКТ послуг до європейського ринку (відносно висока – в Чехії за рахунок державного фінансування, помірна – Польщі через фінансову підтримку держави, Словаччини за рахунок приватних інвестицій у НДДКР, низька – Угорщини), що в майбутньому потребує виваженої інноваційно-інвестиційної стратегії країн, підготовки у достатньому обсязі висококваліфікованих фахівців ІТ галузі, стимулювання приватних інвестицій в НДДКР та кооперації бізнесу зі сферою знань через податкові та адміністративні стимули, сприяння переходу малого та середнього бізнесу на засади економіки 4.0.

Тип статті – емпіричний.

Ключові слова: експортна спеціалізація; європейський ринок; ІКТ послуги; національні стратегії; інноваційно-інвестиційні чинники.

Управление процессом формирования и реализации конкурентных преимуществ стран Вышеградской четверки на европейском рынке ИКТ услуг

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Цель работы – дать оценку интегрированности и управлению процессом формирования и реализации конкурентных преимуществ стран Вышеградской четверки на европейском рынке информационных, компьютерных, телекоммуникационных (ИКТ) услуг на основе их анализа и в отдельных сегментах рынка.

Дизайн/Метод/План исследования. Это исследование нацелено на то, чтобы определить наличие и характер конкурентных преимуществ стран на европейском рынке ИКТ услуг на основе расчета показателей экспортной специализации, установить факторы их наращивания и эффективной реализации по результатам структурного, регрессионного, сравнительного анализа и синтеза.

Результаты исследования. Сделано предположение, что введение европейских правил организации рынка стимулировало наращивание в странах Вышеградской четверки их конкурентных преимуществ на европейском рынке ИКТ услуг за счет инновационно-инвестиционных ресурсов, эффективного управления средствами частного, государственного секторов, средствами международных инвесторов и обеспечения персоналом.

Практическое значение исследования. Присоединение стран Восточной Европы к европейскому цифровук рынку и цифрову пространству требует обобщения опыта стран Вышеградской четверки и определения факторов, направлений и приоритетных задач национальной политики развития ИКТ сектора.

Оригинальность / ценность / научная новизна исследования - на основе расчета индекса сравнительных преимуществ установлена разная интегрированность и результативность управления конкурентными преимуществами стран Вышеградской четверки, в первую очередь, сферы ИКТ услуг к европейскому рынку (относительно высокая – в Чехии за счет государственного финансирования, умеренная – Польши из-за финансовой поддержки государства, Словакии за счет частных инвестиций в НИОКР, низкая – Венгрии), что в будущем требует взвешенной инновационно-инвестиционной стратегии стран, подготовки в достаточном объеме высококвалифицированных специалистов ИТ отрасли, стимулирование частных инвестиций в НИОКР и кооперации бизнеса со сферой знаний через налоговые и административные стимулы, содействие переходу малого и среднего бизнеса на принципы экономики 4.0.

Тип статьи – эмпирический.

Ключевые слова: экспортная специализация; европейский рынок; ИКТ услуги; национальные страте гии; инновационно-инвестиционные факторы.

1. Introduction

Joining in 2004. The countries of the Visegrad Four in the EU meant the spread of European common market rules and competition to national markets and companies in Poland, the Czech Republic, Hungary and Slovakia. In the early 2000s. the EU recognized that the future of a competitive Europe is based on innovation and investment in high-tech industries, including in the ICT field. For ICT companies and the governments of the "new" member countries, this put on the agenda the question of the formation and implementation of competitive advantages in the European market. The proclamation in 2018 by the European Commission of the prospect of building a single digital market for the EU actualizes the management of competitive advantages in the ICT services market.

Prospects for realizing the competitive advantages of the four countries in the European market are primarily associated with their successful integration into the common digital market of the EU. On the one hand, the creation of a digital market will increase the productivity of the economy based on IT technologies and the exchange of knowledge - according to the European Commission, the construction of a DSM should ensure an increase in European GDP of 415 billion euros annually (*European Commission, 2015*). According to expert estimates by McKinsey & Company, the implementation of the latest technologies (including Artificial Intelligence, big data, etc.) should ensure an annual GDP growth of the EU countries by 1.1% by 2030, or a net total increase in size 2200000000000 Euro (*European Commission, 2020a*).

The prospects for realizing the competitive advantages of the four countries in the field of ICTs largely depend on the conformity of national policies with the goals and objectives defined in the framework of the EU research and innovation policy. In particular, V4 countries must become members of the European Digital Space and Digital Single Market (DSM). The digital common market provides freedom of information flow within the EU, complementing the four fundamental freedoms of the common market. Within the digital space, European citizens and enterprises will be able to freely access information, as well as goods and services online, regardless of country of origin (*European Commission, 2015*).

According to the roadmap for building a digital common market, the implementation of 30 legislative acts is planned, 28 of which have already been considered and adopted by the European Parliament and the EU Council (*European Commission, 2018a*). In April 2019, the European Parliament adopted the Digital Common Market Copyright Directive (2019/790), the first of a package of documents within the digital common market that came into force in June of that year (*EUR-Lex, 2019*). Within two years, member countries must bring the national legislation into line with the new directive.

According to the European Commission (*European Commission, 2015*), on average, in every European country 42% of digital services are provided by national providers, 54% by US companies, and only 4% by other member countries within the common market. Building a common digital market will allow European ICT companies to provide services freely to nearly 500 million consumers throughout the common market.

2. Problem statement

The purpose of the work was to assess the management of the process of formation and implementation of the competitive advantages of the Visegrad Four countries in the European market of IC services based on the analysis of their competitive advantages and in its individual segments. To achieve this goal it is necessary to solve the following tasks: to determine the presence and nature of the competitive advantages of countries in the European market of infrared services; establish factors for increasing competitive advantages; evaluate the effectiveness of managing competitive advantages at the national level. We hypothesized that the introduction of European rules for market organization stimulated the build-up of competitive advantages in the European Visegrad Four countries in the European ICT services market through innovative investment resources and effective management of private, public sector and international investors and personnel.

3. Methodology

To determine the competitive advantages of the Visegrad Four countries after joining the EU, we calculated *Balassa (1965)* ICT services (RCA services) indices for each of them, with RCA> 1 indicating the existing competitive advantages. Comparison of the average and initial value of the B. Balassa indices for the period 2004-2017. It allowed to establish the development vector of the competitive advantages of the ICT sector, namely: building up (in the case when the average value exceeds the initial, RCA _ser> RCA _1) or loss of competitive advantages (in the case when the initial value exceeds the average, RCA _ser <RCA _1) for each country. The assessment of the resource base for the formation of competitive advantages in the European ICT services market is based on the construction and analysis of regression models between the values of the competitive advantage indices and the tested factors. Considering the results of *Bochkova (2013)* research and Eurostat statistics, the following indicators were selected as factors in the formation of competitive advantages in the European ICT services market: company spending on R&D — includes expenses of enterprises of all sizes and forms of ownership of R&D only at the expense of their own funds government spending on R&D - defined as the sum of government allocations and other expenses from the state budget for R&D; R&D expenses from funds of foreign origin - include expenses on innovations financed from funds of foreign entities, including foreign companies, European Structural Funds (ESF) and international organizations; the number of employees in R&D - the total number of people employed in research and innovation; average salary of a specialist in the field of ICT services. The calculation of the values of the level and intensity of intra-industry trade (between the countries of the Visegrad Four) made it possible to establish the nature of competition in the ICT services market. The formation of competitive advantages in industries with high trade intensity is stimulated by intense competition, and in industries with high levels of intra-industry trade, it is due to the advantages obtained through economies of scale.

We used the methods of an integrated approach, grouping, average values, structural, comparative, regression analysis and synthesis. The information base for quantitative and qualitative analysis was formed by Eurostat statistics on the development of international trade in ICT services of the Visegrad Four countries (Poland, Czech Republic, Hungary, Slovakia) for the period from 2004 to 2017.

4. Results

The process of "tertization" of economies in the countries of Central and Eastern Europe, based on the transition to market principles of management, accelerated in the Visegrad Four countries with accession to the EU. The "intensification" of the service sector is indicated not only by a change in the structure of the economy, outstripping its growth rates behind the manufacturing sector, but also by qualitative changes in the external sector — the trade and investment sectors (*Melikhova, Bazˇó, Holubcova, & Camacho José, 2015*). For example, *Zhedlichka, Kotian, & Munz (2014)* indicate the increase in the export quota of countries, and the total export of goods from the Visegrad Four countries increased more than 2.5 times during 2003-2013. One of the advantages of the common market is the demonopolization of telecommunications. *Kovárnik and Khamplova (2016)* established different dynamics of export of countries and the attraction of trade flows to Germany (*Kovárník, & Hamplová, 2020*).

Features of the development of the ICT sector of the countries studied by European authors. Thus, the influence of industry (based on the Hershintal index) and regional concentration (according to the Krugman index) ICT sectors on the growth of competitiveness in Poland, the Czech Republic, Hungary, Slovakia and Austria was studied by *Turečkova* (*2016*). Puzhova K. and Mareshova P. assessed the competitiveness of the Czech Republic's ICT industry on the world market (*Půžová, Marešová, 2014*), the "strengths" and "weaknesses" and innovativeness of the ICT sector in Hungary were identified in the work of *Fekó* (*2011*). The regional concentration of ICT complexes in Poland and the Czech Republic was the subject of research by *Schwinta* (*2014*). Thus, the main attention of the authors is focused on the internal laws of the development and competitiveness of the ICT industry, the issue of export specialization and market integration after entry into the EU remain outside the focus of the study.

Szent-Ivany (*2017*) points to the different priority of the ICT sector for foreign direct investors of the four countries. So, for the Czech Republic - 8th place, Poland - 7th, Slovakia - 5th, Hungary - 4th place. The author has identified three groups of challenges that FDI promotion countries of the Visegrad Four are facing, but are still not coping with, including: the changing competitive advantages of V4; the dubious effects of FDI in the long run; the volatile nature of multinational production.

The approximation of the economic structure of the Visegrad four European countries means the formation and deepening of export specialization in the services sector of countries based on comparative / competitive advantages. The most comprehensive study of the competitive advantages of countries, regions and individual firms is presented in M. Porter, the author of the competitive advantage rhombus theory and the theory of the four stages of development of the national economy (*Porter, 1990*). The tools and methods for quantitative assessment of comparative and competitive advantages are given in the work of *Balass* (1965), *Volrat* (*Vollrath, 1991*).

According to the results of 2017, among the four countries only in the Czech Republic and Slovakia competitive advantages expressed by RCA indices > 1 were found. Hungary and Poland showed comparative advantages with the indices of 0.74 and 0.90, respectively.

Table 1

- Competitive advantages of V4 countries and the dynamics of their development in the European ICT services market, 2017 *

Indicator	Czech Republic	Hungary	Poland	Slovakia
Identified comparative and competitive advantages of countries				
RCA_{2017}	1,20	0,74	0,90	1,28
Advantages nature	Competitive	Comparative	Comparative	Competitive
Dynamics of development of comparative and competitive advantages				
RCA_{2004}	0,40	0,80	0,41	0,69
RCA_{cep}	1,00	0,80	0,65	0,91
Growth Rate	2,50	1,00	1,60	1,31

*Source: calculated by the authors based on data *(Eurostat, 2019)*.

Balassa average indices for 2004-2017 are given in table 1. When comparing with the indices for 2004 it can be concluded that all four countries have shown increasing comparative or competitive advantages for the period of EU membership. According to the growth rate, the Czech Republic and Poland showed the greatest value. In Hungary alone, the Balassa index for 2017 was below the 2004 figure and low among the four countries, indicating a relative "closed" market. Our results do not contradict the conclusions of *Turečková* (*2016*), which indicates the narrow industry specialization of the ICT market in Hungary.

A comparative analysis of the Visegrad Four countries allowed *Kovalskaya, Kovarnik, & Khamplova* (*2018*) to establish different significance but the leading role of innovative factors for macroeconomic dynamics and global competitiveness of countries. *Bochkova* (*2013*) considers R&D funding in the Visegrad Four countries to be a leading factor in the competitiveness of the countries of the region. *Kapik, & Drahokoupil* (*2011*) assess FDI in the business services sector as a factor in building the "knowledge economy" of the countries of the region.

The results of an empirical study by *Šebová, & Houdes* (*2012*) point to the close interaction of the knowledge sphere and the ICT sphere in the region of Eastern Slovakia. The authors emphasize the importance of local and translocal interaction in the region and the country, the role of social capital and the existing potential for clustering.

In order to determine the formation factors of the comparative or competitive advantages of the V4 countries, we have constructed models of the linear dependence of the Balass indices for 2004-2017 from the factors listed above. The obtained coefficients of determination are given in *Table 2*.

Table 2

Results of the analysis of the dependence of the RCA index on selected factors for the formation of competitive advantages in ICT services *

Factor	Determination coefficient R^2			
	Czech Republic	Hungary	Poland	Slovakia
R&D expenses of companies	0,51	0,33	0,80	0,64
Public spending on research and development	0,52	0,08	0,86	0,53
Foreign financing of research and development	0,32	0,58	0,56	0,16
Headcount in R&D	0,52	0,39	0,58	0,74
Salary in ICT	0,46	0,10	0,60	0,19

*Source: calculated by the authors based on data *(Eurostat, 2019)*.

It should be noted that the equation of dependence on Czech foreign financing and on the number of employed and wages in Poland received an average approximation error $\bar{A} > 15\%$ (Table 4), which indicates unsatisfactory accuracy of the models. All other equations obtained have a low approximation error, that is, they provide high prediction accuracy and are suitable for use.

To check all the constructed models, one should use the table value of the Fisher criterion F_table = F ((0.05, 1, 12)) = 4.75. The actual values of the Fisher test for each model are given in *Table 3*. Based on the results of the audit, it was found that only models of the dependence on R&D costs at the expense of companies own funds and the number of research personnel are adequate for all four countries with a significance level of α = 0.05. Models of dependence on state funding turned out to be adequate for all V4 countries except Hungary, and on foreign financing for all but Slovakia. Among salary dependence models, only Czech Republic and Poland regression passed the Fisher test.

Table 3

Average approximation errors (A) and actual values of the Fisher test (F) for dependency models

Factor	Czech Republic		Hungary		Poland		Slovakia	
	A, %	F	A, %	F	A, %	F	A, %	F
R&D expenses of companies	12,9	12,5	8,7	5,9	12,8	47,6	8,3	21,8
Government R&D expenditures	13,6	12,9	10,0	1,1	8,6	73,3	9,2	13,3
Foreign R&D funding	15,5	5,7	6,2	16,3	13,8	15,5	13,4	2,3
Headcount in R&D	12,0	13,1	8,1	7,8	18,7	16,7	6,8	34,3
Salary in ICT	14,2	10,2	10,2	1,3	16,5	17,7	13,7	2,9

*Source: calculated by the authors based on data *(Eurostat, 2019)*.

The resulting determination coefficients differ significantly in the countries of the group. Thus, models of the dependence of the Balass indices on R&D costs of enterprises at their own expense showed a close relationship in all four countries, except Hungary (moderate connection at R ^ 2 = 0.33). Indeed, in the structure of the total expenditures of the V4 countries on R&D, the funds of enterprises are the main source of financing (*Table* 4). Nevertheless, the obtained coefficients of determination show that in all four countries, except Slovakia, investment from other sources influenced the formation of the competitive advantages of ICT services to a greater extent. This can be explained by the fact that most of the expenses of private companies were directed to innovations in industry, while the high-tech services sector accounted for less than 20% of total R&D investments (*Eurostat, 2019*).

Table 4

the Structure of the spending of countries V4 on research and development by sources of funding in 2017*

Country	Enterprises		State budget		Foreign sources	
	expenses, million euros	In % of total expenses	expenses, million euros	In % of total expenses	expenses, million euros	In % of total expenses
Czech Republic	1 350,0	39,8	1 186,4	34,9	858,7	25,3
Hungary	881,3	53,0	533,6	32,1	248,9	15,0
Poland	2 539,9	54,3	1 850,5	39,6	287,8	6,2
Slovakia	367,2	49,9	265,9	36,1	102,9	14,0
V4 together	5 138,4	0,49	3 836,4	0,37	1 498,2	0,14

*Source: foldable by authors based on data *(Eurostat, 2019)*.

The relationship between comparative advantage and government spending on R&D was dense in all four countries except Hungary. At the same time, the Polish model (R ^ 2 = 0.86) has the highest determination coefficient, for which public investment in R&D is a strong factor in the development of the competitive advantages of the ICT sector. It should be noted that, in absolute terms, the Polish budget spends significantly more funds on research and development than in other countries - about 18.5 billion euros in 2017. Compared with 1,920,000,000 in the Czech Republic (*Table* 4). In Poland and Slovakia, a significant part of the targeted state support is aimed specifically at the formation of regional IT clusters, the main task of which is to ensure the competitiveness of computer services through the cooperation of education and entrepreneurship (*European Commission, 2020b*).

Models of the dependence of the Balass indices on foreign R&D funding showed a strong dependence (0.5 <R ^ 2 <1) in Hungary and Poland. In absolute terms, the Czech Republic received significantly more investment in R&D from foreign sources than the other four countries - more than 858 million euros in 2017 (*Table* 4). Nevertheless, the obtained coefficients of determination indicate that foreign financing has had the greatest impact on the competitive advantages of ICT services in Hungary, where foreign enterprises and TNC units dominate. According to estimates by the Hungarian Central Statistical Office, about 78% of total research and development costs and 60% of research staff costs are provided by international companies, their units, and joint ventures (*European Commission, 2020b*).

Models of the dependence on the number of personnel employed in R&D showed a strong dependence of all four countries (0.5 <R ^ 2 <1), except Hungary (moderate dependence - 0.25 <R ^ 2 <0.5). Over the years of EU membership, all four countries showed an increase in the number of researchers, Poland showed the greatest growth - almost 1.9 times (*Table* 5). However, compared to other EU countries, the number of people employed in science and technology in V4 countries remains low. In particular, in 2017, IT companies in the Czech Republic, Poland, and Slovakia reported a shortage of specialists from the latest digital and information technologies in general (European Commission, 2020b). But in Hungary, the share of IT graduates is quite high (4.3% versus 3.5% on average in the EU), and the share of IT professionals in the total structure of employees corresponds to the EU average (3.6%) (*European Commission, 2018b*).

Table 5

Comparison of the number of people employed in R&D in V4 countries in 2004 and 2017, thousand people*

Year	Czech Republic	Hungary	Poland	Slovakia
The number of employees in research and development				
2004	60,15	49,62	127,36	22,22
2017	107,73	60,93	239,28	33,47
Growth Rate	1,79	1,23	1,88	1,51
The average monthly salary of employees				
2004	831	858	778	658
2017	1640	1281	1208	1403
Growth Rate	1,97	1,49	1,55	2,13

*Source: foldable by authors based on data *(Eurostat, 2019)*.

The relationship between the average level of wages and competitive advantages was found only in the Czech Republic (moderate connection - 0.25 <R ^ 2 <0.5) and Poland (close connection - 0.5 <R ^ 2 <1). It should be noted that in both countries the relationship between the coefficients of comparative advantages and the level of wages was direct. Although an increase

in salaries leads to an increase in the cost of services provided, the comparative advantage indices also increased (*Table 5*). That is, it cannot be considered that in relation to cheaper labor costs have formed the competitive advantages of the V4 countries in the European ICT services market.

The complex of ICT services includes three categories: telecommunication, computer and information services. To determine the groups of services for which V4 countries have competitive advantages in the European market, we calculated the Balassa indices (*Table 6*). According to the calculations, it was determined that V4 countries have competitive advantages only in the provision of computer services (RCA = 1.01> 1). According to the Eurostat economic activity classifier (NACERev. 2), the category of computer services includes software development services, as well as maintenance and advice on computer equipment. The highest Balass coefficient in this category was shown by the Czech Republic (RCA = 1.24).

Table 6

Indices of the revealed comparative advantages of V4 countries in certain segments of the EU ICT services market in 2017*

Type of service	RCA	Intra-industry trade level, million Euro	ntra-industry trade intensity, %
Telecommunication services	0,81	2353,8	99
Computer services	1,01	7982,2	77
Information services	0,80	789,6	99

*Source: calculated by the authors based on data *(Eurostat, 2019)*.

We also calculated indicators of the level and intensity of intra-industry trade in ICT services of V4 countries with the EU. According to the results of calculations, a high level of intra-industry trade is observed in the provision of computer services, and the highest intensity is in telecommunication and information services (*Table 6*).

Although the level of intra-industry trade of the four countries with computer services in the EU is quite high, the intensity indicator is lower than for other services or, for example, for agricultural products (Dzyad, Krasnikova & Hrechyn, 2019). This is because of the fact V4 countries export much more computer services to EU countries than they import (more than 1.6 times).

Based on the results obtained, it can be concluded that increasing the competitive advantages of the four countries in the European ICT services market depends primarily on the ability of national computer service providers to develop and implement innovations. It should be noted that today the vast majority of V4 countries' investments in R&D are concentrated in industry. Innovation spending in ICTs is less than 15% of total R&D spending of companies in the four countries (*Table 7*).

Table 7

Expenditures of the ICT complex for R&D, 2017*

Indicator	Czech Republic	Hungary	Poland	Slovakia
R&D expenses of the ICT complex, million euros	197,11	60,19	382,00	49,43
Share of ICT in R&D expenses of companies,%	14,6	6,83	15,04	13,46

*Source: calculated by the authors based on data *(Eurostat, 2019)*.

The calculations show the potential for the development of ICT services in the four countries, especially computer services. The reorientation of the research activities of the V4 countries from the needs of industry to the development of ICT services would allow them to be competitive in the European computer services market and export products with a greater share of added value than the current leading export positions - automobiles and cars.

Among the four countries, the Czech Republic, which is one of the five European countries with the largest share of small and medium-sized businesses that provide services or sell goods online (23%) and the largest share of e-commerce in the total turnover of SMEs, should receive the greatest benefits from building a common digital market (18%). However, the lack of IT specialists (which 79% of Czech IT companies reported on) and small volumes of venture financing (less than 1% of GDP, one of the lowest rates in the EU) remain problematic issues (*European Commission, 2018b*).

In this context, the "National Strategy for the Development of the Capital Market" provides for the financing of 20,000 innovative projects in 2020-2050 for a total of 315 billion euros. According to the government program "Czech Republic - the country of the future", by 2030 the country should become a world leader in the field of artificial intelligence. Already today, funding for AI research centers in Prague and Brno exceeds € 250 million; 40% of the total number of industrial robots in the V4 countries work in the Czech Republic. Automation of the Czech industry has doubled the potential economic growth rate to 4% in 2033.

On the other hand, according to government estimates, the implementation of the latest technologies, especially artificial intelligence and automation of production, can crowd out the labor of 3,400,000 Czech workers by 2050 (*European Commission, 2018b*).

The share of the Hungarian ICT sector in the country's GDP is over 5% - the best indicator among the four countries, and the 7th best among the EU countries (*European Commission, 2019*).

In terms of venture investment levels, Hungary also ranks first in V4 with an indicator of almost 6% of GDP (*Eurostat, 2019*). However, 55% of Hungarian companies show very low levels of digitalization, and less than 15% use advanced IT technologies, including cloud and big data (the lowest among the four countries). A shortage of IT professionals is also a characteristic feature of the Hungarian labor market - 75% of IT companies report a lack of staff (*European Commission, 2018b*). In order to meet the demand for qualified personnel in the country, the Hungarian Academy of Sciences has programs to support young researchers (total budget of 14.5 million euros) and a program for the return of emigrant scientists (18.1 million euros). At the same time, the dominant share of investment in innovation (70%) is provided by foreign companies and EU structural funds, while state funding for R&D remains at the level of 2008 (*European Commission, 2019*).

Poland is the largest provider of ICT services among V4 in absolute terms, and ranks ninth among the EU countries (*European Commission, 2019*).

However, only 4% of Polish enterprises export goods or services online, and less than 10% use the latest technology. About a third of Polish companies say that low levels of digitalization are due to the low share of graduates in IT specialties (3.1% compared to 3.5% on average in the EU). Although private investment in R&D has more than quadrupled during EU membership, the growth rate of patent applications and high-tech exports remains moderate (*European Commission, 2018b*).

The "Operational Program for Building Digital Poland" should provide training for specialists in cybersecurity, artificial

intelligence, big data, etc. in 2021-2027, and launched in 2019. Lukashevich's research network will become a platform for cooperation between science and business, especially SMEs.

In Slovakia, research and innovation depends heavily on ESF funding (39%), while the level of business spending on R&D remains one of the lowest in Europe (0.45% of GDP) (*European Commission, 2020b*). As a result, Slovakia is inferior to all V4 countries in the number of high-tech patent applications. To stimulate business investment in 2018 alone, 72 million euros of tax credit were compensated to companies that carried out R&D. To improve the digitalization of the economy (only 13% of companies use the latest technology), the "Slovakia 2030 Digital Transformation Strategy" has been developed, which provides for the creation of regional IT clusters in Bratislava and Zhylin, as well as the creation of the National Center for Artificial Intelligence Research. Slovakia, like the Czech Republic, is one of the world leaders in industrial automation. According to the estimates of Slovak scientists, the deepening of production robotics can change or completely eliminate up to 64% of jobs in Slovakia (*European Commission, 2018b*).

5. Conclusions

The analysis showed that in the Czech Republic and Slovakia the existing ones are competitive, and in Hungary and Poland they have comparative advantages in the EU ICT services market. Ensuring four freedoms, implementing a European competition policy, national efforts on research, innovation, investment and competitiveness in the V4 countries led to an increase in export specialization, which indicates a relatively high integration and effectiveness of competitive advantage management in the Czech Republic, moderate in Poland and Slovakia low - in Hungary. Countries have demonstrated competitive advantage primarily in the computer services segment. According to the results of the regression analysis, it was found that the main factors in the formation of the competitive advantages of the V4 countries in the European ICT services market were investments in development, innovation and R&D. At the same time, in Slovakia the greatest impact was played by companies' investments in research and development, in Hungary - foreign financing of research and development, and in the Czech Republic and Poland - state. Another significant factor was the increase in the total number of specialists involved in R&D.

Building a common digital market will increase competitive pressure on the IT companies of the four countries that will compete with the largest European suppliers (Germany, France, Italy, Spain, Ireland) not only in international but also in national markets. In addition, the latest technology and automation of production require the reorientation of millions of workers in industry to work in the service sector, including in ICT. Therefore, in order to realize the competitive advantages in the European market of ICT services and to benefit from the joint digital market, the V4 countries should: ensure the training of specialized personnel of sufficient quantity and quality; Encourage private investment in R&D and business cooperation with science and education through tax and administrative incentives; promote the digitalization of national economies, especially SMEs.

The practical value lies in the generalized experience of the Visegrad four countries and in determining the factors, directions and priorities of the national policy for the development of the ICT sector in the transition to the digital economy.

Prospects for further research are related to the assessment of socio-economic changes in labor markets under the influence of digitalization.

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7. The competing interests

The authors declare that they have no competing interests.

References

Balassa, B. (1965). Trade Liberalisation and "Revealed" Comparative Advantage. *The Manchester School, 33*(2), 99–123. doi:10.1111/j.1467-9957.1965.tb00050.x.

Bočková, N. (2013). Visegrad Four countries: evaluation in R&D sectors of performance. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis,* 61(4), 873–880. doi:10.11118/actaun201361040873.

Capik, P., & Drahokoupil, J. (2011). Foreign direct investments in business services: transforming the Visegrád four region into a knowledge-based economy? *Journal European Planning Studies*, *19*(9), 1611-1631. doi:10.1080/09654313.2011.586181.

Dzyad, O., Krasnikova, N., Hrechyn K. (2019). Konkurentni perevahy krayin Vyshehrads'koyi hrupy na vnutrishn'omu yevropeys'komu rynku sil's'kohospodars'kykh tovariv [Competitive Advantages of the Visegrad Countries on the European Internal Agricultural Market]. *Infrastruktura rynka [Market Infrastructure],* 31, 19-27. Retrieved from http://market-infr.od.ua/journals/2019/31_2019_ukr/5.pdf (in Ukrainian).

European Commission (2015). Why we need a Digital Single Market – Factsheet. *Publications Office of the EU.* Retrieved from https://ec.europa.eu/commission/publications/why-we-need-digital-single-market_en.

European Commission (2018a). Roadmap for completing the Digital Single Market. *Publications Office of the EU.* Retrieved from https://op.europa.eu/en/publication-detail/-/publication/10dc8396-3dfc-11e8-b5fe-01aa75ed71a1/language-en/format-PDF/source-120120545.

European Commission (2018b). Digital Economy and Society Index 2019 – Country Reports. *Publications Office of the EU.* Retrieved from https://ec.europa.eu/digital-single-market/en/news/digital-economy-and-society-index-desi-2019.

European Commission (2019).The EU ICT sector and its R&D performance. *Digital Economy and Society Index Report,* 2019. *Publications Office of the EU.* Retrieved from https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=59978.

European Commission (2020a). Shaping the digital transformation in Europe – Working paper: Economic potential. *Report/stady. Shaping Europe's digital future.* Retrieved from https://ec.europa.eu/digital-single-market/en/news/shaping-digital-transformation-europe-working-paper-economic-potential.

European Commission (2020b). Research and Innovation Observatory - Horizon 2020 Policy Support Facility. *Publications Office of the EU.* Retrieved from https://rio.jrc.ec.europa.eu/country-analysis.

Eurostat (2019). Database – Eurostat. Retrieved from https://ec.europa.eu/eurostat/data/database.

EUR- Lex (2019). Directive (EU) 2019/790 of the European Parliament and of the Council of 17 April 2019 on copyright and related rights in the Digital Single Market. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019L0790.

Fekó, A. (2011). *ICT industry r&d in Hungary*.Challenges of the Knowledge Society IT, 2011, 2009-20218. Retrieved from https://www.google.com/search?q=ICT+industry+r%26d+in+Hungary.Challenges+of+the+Knowledge+Society+IT%2C&oq=ICT+industry+r%26d+in+Hungary.Challenges+of+the+Knowledge+Society+IT%2C&aqs=chrome..69i57.4578j0j7&sourceid=chrome&ie=UTF-8.

Jedlička, J., Kotian, J., & Münz, R. (2014). Visegrad Four-10 years of EU membership. *Erste Group Research CEE Special Report*, 23 April 2014, 1-23. Retrieved from https://www.erstebank.hr/content/dam/hr/ebc/www_erstebank_hr/misc/press/2014/2014_04_23_EN_Report_Visegrad.pdf.

Kovárník, J., & Hamplová, E. (2016). The analysis of foreign trade development in the countries of Visegrad Four. *XIX. Mezinárodní Kolokvium o Regionálních Vědách. Sborník Příspěvků*. doi:10.5817/cz.muni.p210-8273-2016-30.

Kovárník, J., & Hamplová, E. (2020). Globalization and Foreign Trade: Selected Topics in Central European Countries. *SHS Web of Conferences*, 74, 06014. doi:10.1051/shsconf/20207406014.

Kowalska, A., Kovarnik, J., Hamplova, E., & Prazak, P. (2018). The Selected Topics for Comparison in Visegrad Four Countries. *Economies*, 6(3), 50. doi:10.3390/economies6030050.

Melikhova, Y., Baz˘ó, L., Holubcova, I., & Camacho, J. A. (2015). Trade in services and tertiarisation of the Visegrád Four economies. *Post-Communist Economies*, 27(1), 1–22. doi:10.1080/14631377.2015.992219.

Porter, M. E. (1990). Determinants of National Competitive Advantage. *The Competitive Advantage of Nations*, 69–130. doi:10.1007/978-1-349-11336-1_3.

Kateřina, P., & Petra, M. (2014). Czech Republic's competitiveness in ICT market. *Procedia-Social and Behavioral Sciences, 109*, 880-885. doi:10.1016/j.sbspro.2013.12.558.

Šebová, M., Hudec, O. (2012). The ICT Sector Evolution in an Industrial Region of Slovakia. *Journal of Economics*, 01, 65-82. Retrieved from https://www.researchgate.net/publication/260986987_The_ICT_Sector_Evolution_in_an_Industrial_Region_of_Slovakia.

Szent-Iványi, B. (2017). Investment promotion in the Visegrad four countries: post-FDI challenges. *Condemned to be left behind? Can Central and Eastern Europe emerge from its low-wage mode?* Publisher: ETUI aisbl, Brussels, Editors: Béla Galgóczi, Jan Drahokoupil, 171-188. ISBN 978-2-87452-461-5. Retrieved from https://www.researchgate.net/publication/320417550_Investment_promotion_in_the_Visegrad_four_countries_post-FDI_challenges.

Szwinta, P. (2014). Concentration of the ict industry in the Czech Republic, Germany and Poland. *ACC Journal Science of Economics*, (2), 63-71. Retrieved from http://dspace.tul.cz/bitstream/handle/15240/19886/ACC_2014_2_06.pdf.

Turečková, K. (2016). Sectoral Specialization as a Source of Competitiveness: Case Study on ICT Sector in V4+ Countries. *International Conference on European Integration 2016 Ostrava*, Czech Republic, 1023-1029.

Vollrath, T. (1991). A Theoretical Evaluation of Alternative Trade Intensity Measures of Revealed Comparative Advantage. *Review of World Economics*, 127(2), 265-280.

Appendices

A – Estimated data for regression models

Table A.1

Estimated data for regression models, 2004-2010*

Country	Indicator	2004	2005	2006	2007	2008	2009	2010
Czech Republic	RCA	0,3995	0,8085	1,1083	0,9818	0,8619	1,0145	0,8323
	Expenses of companies, million euros	581,05	617,30	749,20	849,67	900,64	765,11	854,17
	Government spending, million euros	460,79	579,15	686,09	805,37	895,62	919,27	930,98
	Overseas. financing, million euros	40,67	69,08	72,74	130,82	177,63	217,00	291,74
	Headcount	60148	65379	69162	73081	74508	75788	77903
	Salary in ICT, Euro	831	964	1076	1451	1426	1385	1469
Hungary	RCA	0,7967	0,7799	0,8749	0,9015	0,9242	0,9879	0,915
	Expenses of companies, million euros	267,63	330,39	389,92	428,76	511,64	495,46	533,46
	Government spending, million euros	373,71	413,89	403,16	434,12	442,93	448,02	442,97
	Overseas. financing, million euros	74,67	89,38	101,71	108,35	98,22	116,36	139,11
	Headcount	49615	49723	50411	49485	50279	52522	53991
	Salary in ICT, Euro	858	962	954	1129	1125	1053	1045
Poland	RCA	0,4069	0,3418	0,4292	0,4678	0,4776	0,5485	0,6426
	Expenses of companies, million euros	347,11	462,12	499,94	604,17	668,32	567,87	636,62
	Government spending, million euros	702,22	799,68	869,02	1033,6	1311,95	1266,82	1588,88
	Overseas. financing, million euros	58,72	79,59	106,42	118,48	118,90	115,21	308,16
	Headcount	127356	123431	121283	121623	119682	120923	129792
	Salary in ICT, Euro	778	876	980	1024	1174	959	1078
Slovakia	RCA	0,6930	0,6286	0,9173	0,7781	0,7607	0,8255	0,8673
	Expenses of companies, million euros	66,64	71,14	75,70	89,74	105,77	106,38	145,98
	Government spending, million euros	99,39	110,85	120,33	135,93	159,60	153,20	206,4
	Overseas. financing, million euros	7,47	11,74	19,60	25,81	37,48	38,72	61,06
	Headcount	22217	22294	23120	23437	23641	25388	28128
	Salary in ICT, Euro	658	738	824	987	1396	1757	1284

*Source: foldable by authors based on data (*Eurostat, 2019*).

Table A.2

Estimated data for regression models, 2011-2017*

Country	Indicator	2011	2012	2013	2014	2015	2016	2017
Czech Republic	RCA	0,9365	0,9521	0,9816	1,0705	1,0783	1,1387	1,1997
	Expenses of companies, million euros	961,68	1046,88	1126,60	1110,37	1122,17	1171,68	1350,04
	Government spending, million euros	1064,6	1058,3	1041,0	1018,1	1047,0	1055,5	1186,37
	Overseas. financing, million euros	501,65	745,88	813,65	942,01	1056,3	710,52	858,66
	Headcount	82283	87528	92714	97353	100128	99875	107734
	Salary in ICT, Euro	1549	1550	1497	1455	1501	1531	1640
Hungary	RCA	0,7941	0,7302	0,6915	0,7012	0,6784	0,6833	0,7367
	Expenses of companies, million euros	571,74	589,47	662,29	689,88	751,19	773,99	881,31
	Government spending, million euros	458,94	463,54	507,73	478,45	523,15	360,00	533,57
	Overseas. financing, million euros	162,03	193,61	234,47	250,63	225,90	227,48	248,87
	Headcount	55386	56486	58237	57185	56235	54636	60932
	Salary in ICT, Euro	1089	1080	1136	1104	1135	1170	1281
Poland	RCA	0,7142	0,7100	0,7092	0,7845	0,8500	0,8701	0,8997
	Expenses of companies, million euros	797,41	1107,99	1282,74	1506,82	1683,64	2183,81	2539,86
	Government spending, million euros	1582,66	1760,58	1623,47	1747,06	1805,34	1598,07	1850,53
	Overseas. financing, million euros	379,80	457,84	450,77	516,38	722,69	224,86	287,79
	Headcount	134551	139653	145635	153475	157921	171610	239283
	Salary in ICT, Euro	1115	1086	1105	1113	1153	1133	1208
Slovakia	RCA	0,9737	0,9354	0,7372	0,9883	0,9855	1,0952	1,2753
	Expenses of companies, million euros	158,58	220,66	245,54	215,72	232,35	296,21	367,22
	Government spending, million euros	233,06	243,30	237,62	277,11	296,13	262,67	265,91
	Overseas. financing, million euros	66,33	109,15	109,75	158,57	365,64	68,61	102,91
	Headcount	28596	28880	27823	28825	28752	33252	33467
	Salary in ICT, Euro	1353	1416	1387	1324	1325	1337	1403

*Source: foldable by authors based on data (*Eurostat*, 2019).