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The Technological Advantages of the Regions of Central and Eastern Europe

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This paper takes up the problem of the potential technological advantages of the economies of the regions of Central and Eastern Europe. An answer to the question of the directions and change dynamics of technology in the regions of countries that joined the European Union after the year 2003 was sought utilizing the WIPO Technology Concordance Table and the Balassa Revealed Comparative Advantage Index. The main research goals were the identification of potential technological advantages of the regions of Central and Eastern Europe and an assessment of their diversification in an interregional configuration. The basic findings stemming from the conducted analysis are: (1) The level of development of the region defines the number of developing specialties. (2) A convergence effect in the area of technological advantage is observable in the group of the sixteen most developed regions of Central and Eastern Europe.

Keywords: technological advantage, concordance table, revealed comparative advantage index.

Przewagi technologiczne regionów Europy Środkowo-Wschodniej

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W artykule podjęto problem potencjalnych przewag technologicznych gospodarek regionów Europy Środkowo-Wschodniej. Wykorzystując narzędzia w postaci The WIPO Technology Concordance Table oraz indeksu względnej przewagi komparatywnej – Balassa's Revealed Comparative Advantage, poszukuje się odpowiedzi na pytanie o kierunki i dynamikę zmian technologicznych w regionach krajów, które po 2003 r. przystąpiły do Unii Europejskiej. Głównymi celami badawczymi są: identyfikacja potencjalnych przewag technologicznych regionów Europy Środkowo-Wschodniej oraz ocena ich zróżnicowania w układzie międzyregionalnym. Zasadniczymi ustaleniami wynikającymi z przeprowadzonej analizy są: (1) poziom rozwoju regionu determinuje liczbę rozwijanych specjalizacji; (2) w grupie 16 najbardziej rozwiniętych regionów Europy Środkowo-Wschodniej obserwuje się występowanie efektu konwergencji w zakresie przewag technologicznych.

Słowa kluczowe: przewaga technologiczna, tablica konkordancyjna, indeks względnej przewagi komparatywnej.

JEL: O033, O034

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1. Introduction

Manufacturing techniques and technology are micro-economic characteristics whose transposition to the regional level for analysis results in many problems. Accepting that technology signifies the sum total of the processes involving the processing of tangible and intangible goods into useful goods, including specifically the accumulated bundle of scientific and technological knowledge regarding the practical utilization of the achievements of a defined field of science in industry, transportation, medicine, etc. and its transposition and aggregation in a regional view, it shall involve the summing of unit records of the accruing of scientific and technological knowledge within sectors, branches, or technological development areas. It is assumed that unit records materialize the process of accrual of industrial knowledge and potential technological development understood as the set of technical solutions and processes at the disposal of regional economic entities.

A so-defined terminological context leads to the formulation of the two main research goals: identification of potential technological advantages of the regions of Central and Easter Europe and an assessment of their diversification in an interregional arrangement. Tools in the form of the WIPO Technology Concordance Table and the Balassa Revealed Comparative Advantage Index (RCA) were applied in order to achieve the defined research goals.

The structure of this paper is as follows: Section 2 discusses literature on comparative technological advantage. Section 3 contains a description of the methodology and data initially used to achieve this paper's objectives. Section 4 presents the results of the conducted empirical analyses. Section 5 points out the possibilities and limitations of the applied research methodology. The last section sums up the conducted analyses.

2. Technological Comparative Advantage

The concept of technological potential has broad connotations. It may be understood as a set of technological solutions and processes at the disposal of domestic entities, but also has the capability of creating streams of new or improved technological solutions (Stern, Porter and Furman, 2000). Title to the new (or improved) solutions may remain in the management of various entities of the market game. The development of technological potential is the resultant of the capacity to absorb technology transferred from the outside (country / sector of the economy) and the efficiency of the process of its development.

The accumulation of technological development capacity and capability embodied in ownership titles to new technological solutions has been given

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a boost over recent decades due to radical changes in approach and to ways of managing manufacturing processes that are based on intangible resources to an ever increasing degree. However, it should be clearly stressed that depending on cultural or institutional conditions, the dynamics and course of the process of accumulation varies. "The assumption that the dependence between technological change, and the cultural and institutional qualities of a given nation are among the most important reasons behind observable differences in innovativeness and economic growth indicators among individual countries seems justified" (Gomułka, 1998, p. 14).

The results of research into the relations between scientific and industrial achievements and structural changes to the economy launched by J. Schumpeter (1934) especially spotlight technological skills and competencies as prerequisite to achieving comparative advantage (Malerba and Orsenigo, 1995). Compared with traditional assumptions (R. Torrens and subsequently D. Ricardo), the theory of comparative advantage should currently be treated as a logical construct of cohesive generalizations explaining the mechanism of mutually advantageous goods exchange subject to conditions of varied cost effectiveness and potential for applying defined technologies for creating the given goods (bundles of goods).

D. Ricardo's theory continues to be a useful economic model today. This is in spite of the fact that S. Golub and C. Hsieh (2000) demonstrate that apart from the significant usefulness of education, recent decades have been ignoring the model in professional scientific literature mainly due to the initially applied assumptions. They pointed to the 1960s when the model was intensively utilized in economic studies (Stern, 1962; Balassa, 1963, 1965). The beginning of the 21st century is seeing a renaissance of empirical research over comparative advantages (Eaton and Kortum, 2002; Kerr, 2009; Chor, 2010; Levchenko and Zhang, 2012).

The index proposed by Balassa (1965), with its successive modifications, has become universally used – the Revealed Comparative Advantage Index (RCA). In the view of Balassa, this index reveals comparative advantage. If the export share of sector j in country i in the total exports of that country is greater than the share of that sector in the global structure of export, then this is indirect evidence of comparative advantage in the products of sector j of that country in terms of a defined group of countries. It should be noted that changes to the index are the result of not only differences in productivity, but also change brought about by policies stimulating export. It is for this reason that care must be taken in interpreting the results (Posłuszny, 2011). Costinot, Donaldson, and Komunjer (2012), followed by Leromain and Orefice (2013) stress the importance of differences in access and utilization of technology as determinants of the differentiation of models of trade exchange. They also call attention to factors such as geographical distance, colonial ties/legacies, languages, etc. as successive, important determinants in measuring comparative advantages.

This paper utilizes the idea of comparative advantages, giving it a somewhat different meaning and interpretation. Balassa's RCA Index is used to measure potential sources of advantage – i.e. not fully revealed and utilized technological resources in a regional perspective. These resources are the difficult to quantify results of the action of human capital in the form of new scientific and technological knowledge, analyzed from the technological perspective, make it possible to establish the potential of regional economies (research and development competencies, continuity in the development of defined fields of technology, and a capacity for networking) or lack thereof.

3. Research Methodology

The concepts of sector and technological development area describe different aspects of the manufacturing process. They should be analyzed separately. Classifications covering technology and areas of technological development are created and developed by various institutions.[1] In as much as the creation of systematization of technology, although naturally stirring substantive disputes, is not an impossible task, the measurement of the process itself is an enormous challenge to the process of scientific research. It is particularly difficult from a regional perspective. Starting with the general assumption that the description of a new technical solution is an element of the process of technological development, concordance tables are created combining sector classification with the International Patent Classification (IPC), a hierarchical system for classifying inventions. Schmoch (2008) is responsible for significant input into the creation of combination tables. His table served as the basis for the creation of the concordance table of the World Intellectual Property Organization (WIPO), which is used to achieve the research goals of this paper. The attachment (Table 1) presents the classification of areas of technological development using the IPC system.

The creation of technological fields utilizing the IPC system should be considered a valuable way of meeting the problems of measuring the direction and dynamics of changes in technological development in each layer of economic analysis. Defects in patent metadata are compensated for by the possibility of treatment of complete sets that often consist of hundreds of thousands of objects (when national economies are examined).

Using the concept of the price index for Balassa's relative sizes (1963, 1965), which are applied in international comparisons by Eaton and Kortum (2002), Chor (2010), Nesta and Patel (2005), Kerr (2009), and Levchenko and Zhang (2012), below it receives the following meaning:

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$$RPTA_{ik} = \left(\frac{P_{ik}}{\sum_k P_{ik}} \right) \Big/ \left(\frac{\sum_i P_{ik}}{\sum_{ik} P_{ik}} \right) \tag{1}$$

Where:

$RPTA_{ik}$ – Relative potential technological advantage of region i when applying the concordance table (see attachment) combining technological areas and the international patent classification, where the individual parameters of Formula 1 may be assigned the following meanings:

P_{ik} – Number of technical solutions of region i in technology area k.

$\Sigma_k P_{ik}$ – Total number of technical solutions of region i in all examined technology areas.

$\Sigma_i P_{ik}$ – The total number of technological solutions in technology area k for all examined regions i.

$\Sigma_{ik} P_{ik}$ – The total number of technological solutions in all technology areas for all examined regions.

The index value belongs to the RPTA $\in (0; +\infty)$ set. A value greater than one indicates relative technological advantage within the examined set (e.g., a define set of European regions). A value less than one indicates a relatively weak competitive position in the defined field of technology against a background of the others. The log of the formula may be taken, which gives log(RPTA) $\in$ R. The threshold value for interpreting advantages/weaknesses then becomes zero. Positive values for the examined country indicate potential areas of technological advantage, while negative values show areas where the situation is not favorable. The result of the simple modification

$$(\text{RPTA} - 1)/(\text{RPTA} + 1) = \text{RPTA}^* \text{ becomes } \text{RPTA}^* \in [-1; +1].$$

The value of RPTA is the resultant of the operation of two factors: the unit dynamics for the relative sizes and changes in the structure of those factors.

4. Analysis Results: A Presentation

By using the relation of the absolute measure of dispersion – standard deviation (σ) and mean value (μ) – what is received in the classic coefficient of variability (V_j) that determines the degree of divergence of technological specialization over the examined time period and space, where the greater the dispersion the narrower the technological specialization of the country. Low values for this characteristic can be interpreted as relatively evenly distributed technological competencies in the area of the whole population of technological development areas being considered. In examining the above relations from the perspective of technology, it is possible to identify the relative technological advantage of the country as well as indicate the degree of its diversification in the examined group. A higher variability index value points to emerging technological specialization. A lower value indicates a poorly exploited area or one that is exploited b all countries to a similar extent and with similar search results.

The attachment (Table 2) presents the accumulated values for the RPTA index received thanks to use of the set of patent metadata of the European Patent Office (EPO) and the technology combination table (attachment, Table 1). The following findings for the regions of Central and Eastern Europe stem from the attached Table 2:

1) A RPTA index value greater than one indicates relative technological advantage in the area of the examined population (i.e. fifty-six European regions). Bearing in mind this criterion, the following leaders need to be identified – i.e. regions with the greatest number of technologies where comparative advantage is maintained: (1) Voivodeship of Mazovia (fourteen fields of technological development), (2) Prague (thirteen technological fields), (3) Észak-Magyarország and Zahodna Slovenija (twelve technological fields each), (4) Nyugat-Dunántúl, Dél-Alföld, and the voivodeships of Łódź and Lesser Poland, and Bucureşti-Ilfov (eleven each), and (5) Jihovýchod, Střední Morava, Közép-Magyarország, and Bratislavský kraj (ten technological development fields each).
2) Regions with the lowest number of relative technological advantages include: (1) the Romanian Sud-Vest Oltenia region (lack of any relative advantage in any technological field whatsoever), (2) the voivodeships of Kuyavia-Pomerania and Warmia-Masuria, and the Romanian Vest (one comparative advantage each), (3) the Bulgarian regions of Severozapaden and Yugoiztochen, the voivodeships of Świętokrzyskie and Opole, and the Romanian Centru and Sud-Muntenia regions (two relative technological advantages each), and (4) the voivodeships of Podlasie and Western Pomerania and the Romanian Nord-Vest and Sud-Est (three specializations each).
3) The greatest technological concentration is observable in semiconductor technologies, where only the Voivodeship of Mazovia and the Zahodna Slovenija region can boast certain achievements in this area.
4) An equally high concentration is visible in audio-visual technologies, chemical and nuclear engineering, optics, space technologies, surface technologies, and thermal processes and equipment.
5) The most intensive and balanced development is in the area of consumer articles and equipment and organic chemistry.
6) Differentiation in the area of numbers of developed fields of technology is generally determined by the size of the region's economy.

Table 1 presents changes in patent activity of the sixteen most rapidly developing regions of Central and Eastern Europe.

 DOI 10.7172/1644-9584.62.11

Quartile groups	Years		
	2005	2010	2014
First	Közép-Magyarország Zahodna Slovenija Vzhodna Slovenija Prague	Közép-Magyarország Zahodna Slovenija Prague Mazovia	Közép-Magyarország Mazovia Prague Vzhodna Slovenija
Second	Jihovýchod Mazovia Croatia Dél-Alföld	Łódź Střední Čechy Vzhodna Slovenija Lesser Poland	Lesser Poland Zahodna Slovenija Łódź Greater Poland
Third	Yugozapaden Severovýchod Bratislavský kraj Lesser Poland	Severovýchod Jihovýchod Greater Poland Bratislavský kraj	Střední Čechy Jihovýchod Silesia Severovýchod
Fourth	Greater Poland Silesia Střední Čechy Střední Morava	Silesia Dél-Alföld Yugozapaden Střední Morava	Střední Morava Dél-Alföld Yugozapaden Bratislavský kraj

Tab. 1. Quartile groups for the sixteen regions of Central and Eastern Europe achieving the highest number of patent monopolies through European submission procedures. Source: own work.

The following findings may be derived from analysis of Table 1:

1) The Hungarian Közép-Magyarország region and Prague were always present in all the examined time points in the first quartile group;
2) The Zahodna Slovenija and Vzhodna Slovenija regions as well as the Voivodeship of Mazovia were in the first or second quartile group in the decided majority of cases;
3) The most recent five years brought increased activity to Polish regions, where three or four voivodeships make their appearance each and every time in the first two quartile groups of the set;
4) Table 1 together with an in-depth analysis of codependence for the whole research period indicate the instability of the examined quartile groups as a noticeable convergence effect in the area of examined technological activity (the values of the coefficient of variation based on standard, average, and quarterly deviations decrease with time).

The above analysis was enriched by a cluster analysis (Everitt, Landau, Leese, and Stahl, 2011; Kaufman and Rousseeuw, 2005). Euclidian distances were used to calculate distances between individual technologies:

$$dist_{ij} = \sqrt{\sum_{k=1}^{p}(x_{ik} - x_{jk})^2}$$

Where:
$dist_{ij}$ – Value of the distance between developed technologies within the regions,
p – Number of regions developing the given technology,
x_{ik}, x_{jk} – Successive quality values, and
k – Successive object subject to analysis.

A matrix of Euclidian distances for individual technologies was received as a result of the conducted calculations. Furthermore, the arithmetic mean of the distance between all pairs of elements were used to calculate the distances between concentrations (technology groups) in line with the equation below:

$$d(r,s) = \frac{1}{n_r n_s} \sum_{i=1}^{n_r} \sum_{j=1}^{n_s} dist(x_{ri}, x_{sj})$$

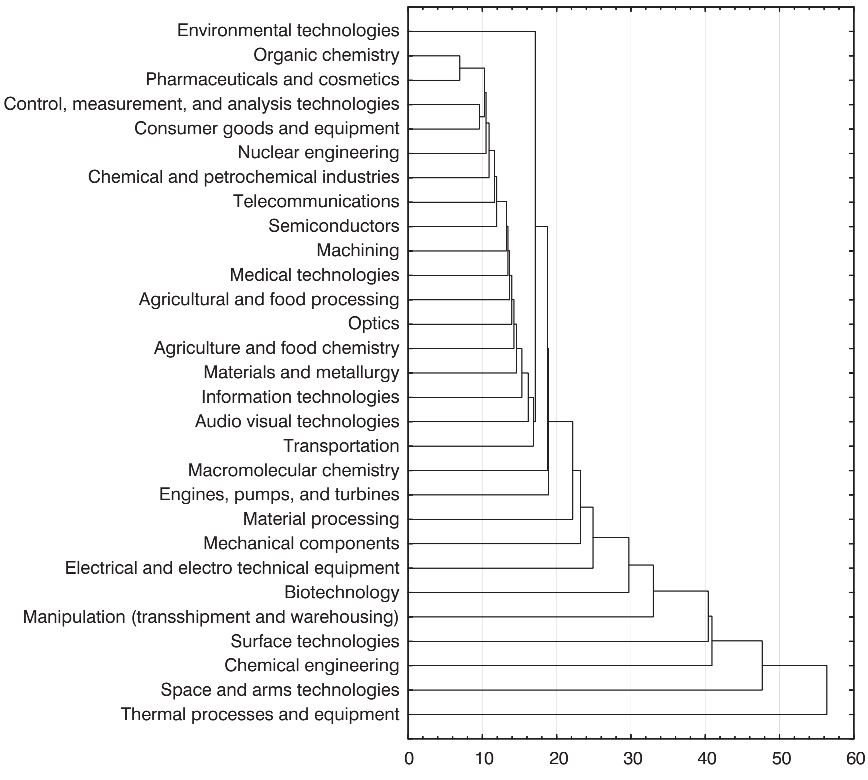

Fig. 1. Dendrogram for technology concentrations for the group of fifty-six regions of Central and Eastern Europe. Source: own work.

 DOI 10.7172/1644-9584.62.11

Where:

d(r,s) – The value of the distance between individual concentrations of technology subject to analysis,

n_r , n_s – Number of elements in the given *r* and *s* technology concentrations,

x_{ri} , x_{sj} – Successive element in the concentration, and

dist (x_{ri} , x_{sj}) – Successive values for distances between elements x_{ri} and x_{sj}.

A dendrogram was development for each analyzed technology pair within the area of the analyzed regions on the basis of the conducted calculations. They present a subdivision into technology concentrations stemming from Euclidian distances between standardized values of qualities and the arithmetic mean of distances between concentrations.

Examination of the figure leads to the striking of the following technology groups in the group of jointly analyzed regions:

1) First, encompassing twenty relatively evenly developed technology fields,
2) Second, technologies involving material processing, mechanics, electro-technology, and biotechnology, and
3) Third, surface technologies, chemical engineering, space technologies, and thermal processes and equipment.

5. Methodological Restrictions

The methodological discussion on the scope and ways of utilizing patent statistics in economic studies (Basberg, 1987; Pavitt, 1985; Archibugi, 1992; Griliches, 1990; Hinze and Schmoch, 2005; OECD, 2009) is not wide-ranging when compared with methodological discussions in the area of innovation or bibliometry. The methodology for utilizing the sets of patent information was generally in the shadow of the research initiative, that is innovation statistics using the methodological recommendations of the Oslo Manual, especially the Community Innovation Survey international research program. In spite of the fact that defects of the patent indexes as measures of innovation are stressed so often, they are consistently used as measures of the phases of innovation activities.

Research into innovativeness does not provide knowledge on the accumulation of technology and technical change directly. Patent information provides greater possibilities in this area. It delves deeper into these processes as compared with other alternative methodological approaches. Its main advantage is high flexibility of aggregation as well as disaggregation of the examined processes. It makes possible the identification of the strategy of directions of future development. Patent information as well as overviews of innovativeness deliver the most important knowledge on the directions and dynamics of technological change on a micro-, mezzo-, and macroeconomic level.

6. Conclusions

The conducted analysis of potential, relative technological advantages in fifty-six regions of the countries of Central and Eastern Europe allows the extraction of the following general conclusions:

1) The level of development of a region is determined by the number of developed specializations, where the largest regional economies are characterized by the greatest diversification in potential technological advantages, while the smallest economies demonstrate very narrow specializations;
2) Regions with the largest numbers of technologies maintaining comparative advantage are the Voivodeship of Mazovia, Prague, Észak-Magyarország, Zahodna Slovenija, Nyugat-Dunántúl, Dél-Alföld, the voivodeships of Łódź and Lesser Poland, Bucureşti-Ilfov, Jihovýchod, Střední Morava, Közép-Magyarország, and Bratislavský kraj;
3) Among the regions with the lowest number of relative technological advantages are the Romanian Sud-Vest Oltenia regions, the voivodeships of Kuyavia-Pomerania and Warmia-Masuria, the Romanian Vest, the Bulgarian Severozapaden and Yugoiztochen regions, the voivodeships of Świętokrzyskie and Opole, the Romanian Centru and Sud-Muntenia, the voivodeships of Podlasie and Western Pomerania, and the Romania Nord-Vest and Sud-Est;
4) The lowest potential technological advantages (jointly for all regions) can be observed in semiconductor and audio-visual technologies, chemical and nuclear engineering, optics, space technologies, surface technologies, and thermal processes and equipment;
5) The relatively high competitiveness (in the case of all regions examined jointly) may be observed in the areas of organic chemistry and consumer equipment;
6) Quartile analysis combined with the analysis of codependence in the group of the sixteen most developed regions indicate the existence of a convergence effect in the area of technological advantage.

Endnote

1 See the *Foresight* list of technological projects implemented in the European Union.

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Attachments

No.	Technological area	Level of IPC classes and subclasses
1	Environmental technologies	A62D, B09, C02, F01N, F23G, F23J
2	Organic chemistry	C07C, C07D, C07F, C07H, C07J, C07K
3	Macromolecular chemistry and polymers	C08B, C08F, C08G, C08H, C08K, C08L, C09D, C09J
4	Pharmaceuticals and cosmetics	A61K
5	Biotechnology	C07G, C12M, C12N, C12P, C12Q, C12S
6	Agricultural and food processing (machines and equipment)	A01B, A01C, A01D, A01F, A01G, A01J, A01K, A01L, A01M, A21B, A21C, A22, A23N, A23P, B02B, C12L, C13C, C13G, C13H
7	Agriculture and food chemistry	A01H, A21D, A23B, A23C, A23D, A23F, A23G, A23J, A23K, A23L, C12C, C12F, C12G, C12H, C12J, C13D, C13F, C13J, C13K
8	Optics	G02, G03B, G03C, G03D, G03F, G03G, G03H, H01S
9	Control, measurement, and analysis technologies	G01B, G01C, G01D, G01F, G01G, G01H, G01J, G01K, G01L, G01M, G01N, G01P, G01R, G01S, G01V, G01W, G04, G05B, G05D, G07, G08B, G09B, G09C, G09D, G12, G08G
10	Medical technologies	A61B, A61C, A61D, A61F, A61G, A61H, A61J, A61L, A61M, A61N
11	Chemical engineering	B01, B02C, B03, B04, B05B, B06, B07, B08, F25J, F26
12	Chemical and petrochemical industries, material chemistry	A01N, C05, C07B, C08C, C09B, C09C, C09F, C09G, C09H, C09K, C10B, C10C, C10F, C10G, C10H, C10J, C10K, C10L, C10M, C11B, C11C, C11D
13	Material processing, textiles, and paper	A41H, A43D, A46D, B28, B29, B31, C03B, C08J, C14, D01, D02, D03, D04B, D04C, D04G, D04H, D06B, D06C, D06G, D06H, D06J, D06L, D06M, D06P, D06Q, D21
14	Machining	B21, B23, B24, B26D, B26F, B27, B30
15	Mechanical components	F15, F16, F17, G05G

No.	Technological area	Level of IPC classes and subclasses
16	Manipulation (transshipment and warehousing), printing	B25J, B41, B65B, B65C, B65D, B65F, B65G, B65H, B66, B67
17	Engines, pumps, and turbines	F01 (excluding F01N), F02, F03, F04, F23R
18	Nuclear engineering	G21, H05G, H05H, G01T
19	Materials and metallurgy	C01, C03C, C04, C21, C22, B22
20	Surface technologies (shells)	B05C, B05D, B32, C23, C25, C30
21	Thermal processes and equipment	F22, F23B, F23C, F23D, F23H, F23K, F23L, F23M, F23N, F23Q, F24, F25B, F25C, F27, F28
22	Transportation	B60, B61, B62, B63B, B63C, B63H, B63J, B64B, B64C, B64D, B64F
23	Space technologies and arms	B64G, F41, B63G, C06, F42
24	Electrical and electro-technical equipment, electrical energy	F21, G05F, H01B, H01C, H01F, H01G, H01H, H01J, H01K, H01M, H01R, H01T, H02, H05B, H05C, H05F, H05K
25	Semiconductors	H01L
26	Information technologies	G06, G11C, G10L
27	Telecommunications	G08C, H01P, H01Q, H03B, H03C, H03D, H03H, H03K, H03L, H03M, H04B, H04H, H04J, H04K, H04L, H04M, H04Q
28	Audio-visual technologies	G09F, G09G, G11B, H03F, H03G, H03J, H04N, H04R, H04S
29	Consumer goods and equipment	A24, A41B, A41C, A41D, A41F, A41G, A42, A43B, A43C, A44, A45, A46B, A47, A62B, A62C, A63, B25B, B25C, B25D, B25F, B25G, B25H, B26B, B42, B43, B44, B68, D04D, D06F, D06N, D07, F25D, G10B, G10C, G10D, G10F, G10G, G10H, G10K, E01, E02, E03, E04, E05, E06, E21

Tab. 1. Classification of technology areas utilizing the IPC. Source: Schmoch U. (2008), Concept of a Technology Classification for Country Comparisons. Final Report to the World Intellectual Property Organisation, Fraunhofer Institute for Systems and Innovation Research, Karlsruhe, pp. 5–10.

Area of technological development (see Table 1)	Severozapaden	Severen tsentralen	Severoiztochen	Yugoiztochen	Yugozapaden	Yuzhen tsentralen	Prague	Střední Čechy	Jihozápad	Severozápad	Severovýchod	Jihovýchod	Střední Morava	Moravskoslezsko	Estonia	Croatia-Adriatic	Croatia-Continental	Közép-Magyarország	Közép-Dunántúl	Nyugat-Dunántúl	Dél-Dunántúl	Észak-Magyarország	Észak-Alföld	Dél-Alföld	Lithuania	Latvia	Łódź	Mazovia
1	0.0	0.0	0.0	0.0	0.8	0.0	0.6	1.0	8.5	0.0	0.0	3.3	0.0	1.9	0.0	2.3	0.0	0.8	9.6	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.3
2	0.0	1.4	0.0	0.0	0.4	0.0	2.1	0.0	0.7	1.0	0.0	0.4	0.6	0.3	0.0	0.0	0.0	1.3	0.9	0.0	1.4	0.3	0.5	0.0	1.2	2.4	1.2	1.6
3	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	12.5	1.4	2.3	0.0	0.0	0.0	0.0	0.0	0.5	5.7	0.0	0.0	3.7	0.0	0.0	0.0	0.0	5.7	1.2
4	3.9	0.0	0.0	0.0	1.3	0.7	0.6	0.5	0.0	0.0	0.4	0.9	0.7	0.0	0.5	0.4	0.0	1.7	0.3	0.0	1.6	0.0	3.3	0.8	0.0	1.7	0.3	0.4
5	0.0	0.0	0.0	0.0	0.5	0.0	1.6	0.0	0.0	0.0	0.0	0.5	0.8	0.0	2.4	0.0	0.0	0.4	2.2	0.0	4.2	0.0	4.5	1.4	0.0	3.2	1.1	1.9
6	0.0	0.0	0.0	0.0	0.9	5.3	0.3	1.2	0.0	0.0	0.0	2.3	2.7	0.0	1.4	0.0	0.0	0.6	0.0	5.1	0.0	4.9	9.4	4.6	4.9	0.0	0.0	0.4
7	0.0	0.0	0.0	0.0	1.6	3.2	0.2	0.0	0.9	5.0	1.1	0.0	0.0	0.0	0.8	0.0	0.0	1.3	0.0	3.1	8.4	2.9	2.3	5.5	5.8	1.1	0.0	1.2
8	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	1.8	0.0	2.5	0.0	0.0	0.0	1.1	4.9	0.0	0.6	1.6
9	0.0	0.0	0.0	0.0	1.5	2.2	1.3	0.5	0.0	0.0	1.6	0.6	0.6	0.9	2.9	1.1	0.0	0.9	1.6	1.1	0.0	0.0	0.0	1.9	0.0	0.0	0.3	1.7
10	0.0	4.2	0.0	10.6	0.3	0.0	0.5	1.7	1.6	0.0	0.0	1.1	0.0	0.0	3.9	1.9	0.0	0.9	0.0	0.9	0.8	3.5	0.0	1.2	0.0	1.3	1.2	2.1
11	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	2.9	5.7	1.3	1.6	0.9	1.5	0.0	0.0	0.0	1.1	0.0	1.7	0.0	0.0	2.6	1.6	0.0	1.2	2.2	0.8
12	0.0	0.0	6.7	0.0	1.3	0.0	1.2	0.0	0.0	0.0	0.0	0.5	0.9	0.0	0.9	0.0	0.0	1.9	2.6	0.0	1.6	1.7	0.0	0.8	0.0	0.0	1.8	0.8
13	0.0	12.0	5.0	0.0	0.5	0.0	0.2	0.0	0.0	0.0	16.4	0.4	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.9	2.9	0.4
14	0.0	0.0	0.0	0.0	3.0	0.0	0.6	0.0	0.8	0.0	0.5	2.9	2.2	2.4	0.7	1.4	0.0	1.0	0.0	0.0	0.0	4.0	0.0	3.7	0.0	0.0	0.3	0.0
15	0.0	0.0	10.7	0.0	0.5	0.0	0.6	0.6	0.8	4.6	0.5	0.8	0.0	1.2	0.7	0.0	0.0	0.5	0.0	1.4	1.3	0.0	0.0	0.0	0.0	0.0	1.4	0.7
16	0.0	0.0	0.0	0.0	2.4	6.8	0.4	0.5	4.3	0.0	0.4	0.7	0.6	1.0	2.9	1.1	0.0	0.7	2.4	1.1	0.0	0.0	0.0	0.5	2.1	0.0	1.4	0.9
17	0.0	0.0	0.0	21.2	8.0	3.9	2.2	0.8	0.0	0.0	0.0	0.6	0.0	0.0	5.9	3.9	0.0	0.4	1.4	1.8	1.7	1.8	0.0	0.0	7.1	2.7	0.0	0.6
18	0.0	0.0	0.0	0.0	0.0	0.0	5.8	0.0	8.0	0.0	0.0	4.3	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3
19	0.0	0.0	0.0	0.0	2.9	4.3	1.1	0.9	1.1	0.0	0.0	0.6	2.1	9.0	1.1	0.0	0.0	0.5	3.0	0.0	0.0	0.0	0.0	2.8	0.0	2.9	0.5	1.6
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	1.7	0.0	0.0	0.0	0.0	0.3	0.0	3.2	0.0	9.1	0.0	0.0	0.0	0.0	3.2	3.6
21	0.0	0.0	10.2	0.0	0.0	0.0	1.8	0.0	3.0	0.0	1.0	0.8	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	2.6	0.0	0.0	5.1	0.0	0.0	0.9
22	0.0	4.1	0.0	0.0	0.3	3.8	1.6	10.4	0.0	0.0	0.3	0.3	2.8	4.8	0.0	2.8	0.0	0.4	0.7	3.6	0.8	0.0	0.0	0.4	0.0	0.6	0.0	1.0
23	0.0	0.0	0.0	0.0	0.0	0.0	3.7	5.4	0.0	0.0	2.9	3.6	4.1	10.5	0.0	4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3
24	11.6	0.0	0.0	0.0	0.0	0.0	0.3	0.0	2.3	0.0	0.4	0.6	4.2	0.0	1.1	0.0	0.0	1.3	1.5	0.0	0.0	0.0	0.0	0.9	1.9	0.0	0.0	0.5
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.2
26	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	2.4	0.0	7.3	4.8	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0	0.6	2.1	0.0	0.0	0.0	0.0	2.4	0.0	0.0	4.8	0.0	0.1	0.0	0.0	0.0	4.4	3.4	2.1	0.0	0.0	0.0	1.5
28	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0	0.0	1.3	0.0	0.5	0.0	0.5	1.1	1.1	2.2	1.0	1.9	0.7	1.2	0.4	2.5	0.0	0.7	0.8	2.4	0.3	0.7	0.5	1.1	0.7	0.2	2.0	0.6
RPTA > 0	2	4	5	2	9	7	13	6	9	6	7	10	10	8	9	11	0	10	9	11	7	12	6	11	8	8	11	14
V_i	414	317	251	389	157	184	106	226	178	250	296	104	114	213	160	147	0	61	183	143	223	145	223	137	182	157	144	124

Tab. 2. RPTA with the fifty-six regions of Central and Eastern Europe. Source: own work.

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Area of technological development (see Table 1)	Lesser Poland	Silesia	Lublin	Subcarpathia	Świętokrzyskie	Podlasie	Greater Poland	Western Pomerania	Lubusz	Lowe Silesia	Opole	Kujyavia-Pomerania	Warmia-Mazuria	Pomerania	Nord-Vest	Centru	Nord-Est	Sud-Est	Sud-Muntenia	București-Ilfov	Sud-Vest Oltenia	Vest	Vzhodna Slovenija	Zahodna Slovenija	Bratislavský kraj	Západné Slovensko	Stredné Slovensko	Východné Slovensko	V_i
1	1.6	2.0	5.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	3.9	9.0	5.0	0.0	219
2	0.6	2.1	0.7	0.0	0.0	0.0	0.1	0.0	0.0	0.3	0.0	0.9	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.9	1.0	0.0	0.4	0.0	134
3	0.0	0.0	8.8	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	0.0	0.0	0.0	0.0	0.0	0.7	0.5	5.2	0.0	0.0	0.0	240
4	0.9	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.3	0.0	0.0	0.0	1.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.7	1.3	0.5	0.0	0.8	0.0	153
5	0.6	0.0	0.0	0.0	0.0	0.0	2.3	20.8	0.0	2.8	0.0	0.0	0.0	2.2	19.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.1	0.0	0.0	1.7	0.0	280
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	2.5	0.0	0.0	0.0	0.0	223
7	0.6	0.7	0.0	5.0	0.0	0.0	0.6	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	2.9	176
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5	0.0	0.0	0.0	0.0	0.0	0.5	1.8	0.0	0.0	0.0	0.0	352
9	0.4	0.0	0.0	0.0	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	1.1	0.0	0.0	1.8	1.7	1.4	4.5	0.0	0.0	165
10	2.7	1.7	2.1	0.0	0.0	0.0	0.4	0.0	1.6	0.8	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.5	0.7	2.5	0.0	0.0	0.0	176
11	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	39.9	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	2.2	0.7	2.3	0.0	0.0	3.3	390
12	0.0	0.0	4.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	0.0	0.0	0.3	0.0	2.4	0.0	0.0	0.0	215
13	0.5	0.6	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.7	0.6	0.0	7.5	2.5	296
14	1.0	0.0	9.5	2.3	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	1.2	0.0	2.9	0.0	0.0	206
15	1.0	0.6	0.0	2.3	0.0	0.0	1.6	9.6	9.9	2.6	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	6.4	1.5	0.0	0.0	2.8	1.4	1.3	0.0	0.0	13.4	195
16	2.4	1.5	0.0	5.4	0.0	0.0	2.1	0.0	0.0	2.0	12.5	0.0	0.0	3.1	0.0	12.5	0.0	0.0	0.0	0.0	0.0	25.1	1.4	0.2	0.0	2.3	0.0	2.1	224
17	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	6.1	0.0	0.0	0.0	0.0	3.9	0.0	0.0	0.0	0.5	1.7	0.0	2.1	0.0	223
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	382
19	0.0	2.8	0.0	3.4	0.0	0.0	0.8	0.0	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.6	2.8	4.3	0.0	0.0	183
20	1.2	1.5	0.0	0.0	0.0	0.0	0.0	7.3	22.5	0.0	0.0	0.0	0.0	0.0	0.0	36.6	5.6	0.0	0.0	0.0	0.0	0.0	1.2	0.9	0.0	0.0	0.0	0.0	327
21	3.9	0.0	0.0	8.7	0.0	24.5	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.3	49.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	3.1	0.0	321
22	0.0	1.7	4.1	5.9	0.0	4.1	1.1	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	1.0	0.6	0.8	3.8	3.1	1.7	158
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1	0.0	347
24	0.0	1.4	0.0	0.0	0.0	0.0	0.8	0.0	0.0	6.5	0.0	17.5	0.0	0.0	0.0	0.0	3.6	11.6	0.0	5.3	0.0	0.0	1.5	1.3	0.9	2.1	0.0	0.0	235
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.1	0.0	0.0	0.0	0.0	530
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.1	0.0	0.0	4.8	0.0	0.0	0.0	3.9	0.0	0.0	0.0	0.0	272
27	3.4	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	1.7	5.8	0.0	0.0	0.0	0.0	213
28	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	4.0	0.0	0.0	0.0	403
29	2.0	1.6	0.0	0.0	5.9	3.1	3.3	0.0	0.0	0.9	0.0	1.0	0.0	1.0	2.2	0.0	0.0	2.0	0.0	1.1	0.0	0.0	1.4	1.0	0.9	0.7	0.8	1.3	106
RPTA > 0	11	10	6	7	2	3	9	3	6	7	2	1	1	6	3	2	7	3	2	11	0	1	9	12	10	7	7	7	
V_i	123	124	217	200	367	412	125	328	238	182	426	478	529	198	386	412	218	346	470	157	0	530	95	130	127	202	199	271	

Tab. 2. RPTA with the fifty-six regions of Central and Eastern Europe (continued). Source: own work.