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CREATION OF HIGH TECHNOLOGIES: COMPARATIVE ANALYSIS OF COUNTRIES

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Abstract

Research purpose. High technology creation, as a rule, requires national support systems although the flow of the created value in an international level is unexplored. The national innovation systems are becoming globalized; thus the distinct process of creation, dissemination and implementation of high technologies is becoming globally fragmented and therefore the added value distribution within the global value chain (GVC) should be investigated.

Design/Methodology/Approach. The brief and extensive academic literature review dedicated to high technology creation is introduced, although the empirical investigation is narrowed to the scientific research and development sector, depicted as M72 by NACE statistical classification. Thus empirical research design is based on the sectoral level data, considering M72 sector as the main economic activity for high technology creation. The data for the comparative analysis of countries is retrieved from the 2014 world input–output data (WIOD) which enables to exclude double counting of added value inherent for the convenient import and export data and holds information of intermediate and final consumption of added value within a country and between different countries. The descriptive statistic based on WIOD data is provided and further prescriptive statistics for the data interpretation is conducted. While developing the predictive models, the number of investigated countries varies while the data for M72 sector is not available for all countries provided in WIOD and including to the model basic science and technology indicators as independent variables, retrieved from the Organisation for Economic Co-operation and Development database, the number of countries reduced additionally, also due to the data shortage.

Findings. The key result is the provided methodology for the positioning of the countries evaluating the involvement in the upstream and downstream GVC processes, hereby introducing new indicators that may have an impact on the sector's performance.

Originality/Value/Practical implications. The evaluation of high technologies creation performance would provide insights into the international management and innovation policies, and the matrix concept for the positioning countries by the pattern of involvement to the GVCs could be applied to other sectors.

Keywords: high technologies sector; global value chain; comparative analysis of countries.

JEL codes: F60; O30; O57.

Introduction

There is a broad consensus that investments to the high technology sectors are central for economic productive capacity expansion and sustainable development. The economic activity of scientific research and development is considered as a pivot source of technology creation, and thus the output of the M72 sector by NACE classification. The aim of this research is to introduce new indicators for the perception of the complexity of the creation of high technologies in the international environment. The proposed method enables the positioning of the countries' scientific research and development sector's involvement in the global value chains (GVCs) pattern. The introduced matrix model for these indicators reveals the upstream and downstream involvement of the scientific research and development sector's in the GVC. This comparative analysis of countries identifies the scientific research and development sector's involvement in the GVC pattern, but does not disclose the impact on the creation of added value of the M72 sector. Therefore the linear regression model is applied to verify if the scientific research and development sector's process involvement into upstream and downstream GVC has no relation with this sector's performance: the share of added value from the overall added value of the country.

Thus in this research, the comparative analysis of the countries in the sectoral level is conducted by applying the proposed matrix model and also the linear regression models for the evaluation of the impact of developed indicators on the scientific research and development sector's significance to the domestic economy. The generated linear regression model results exposed that the lower level of the downstream involvement into the GVC of scientific research and development sector has a negative impact on this sector's performance relative to the overall sectors in the country, and business investments have almost twice higher impact on the scientific research and development sector's activities.

Literature review

The creation of technologies is a specialized activity with the dedicated departments in private companies and public sector institutions in distinct technological fields. This specialization enabled to effectively develop scientific and knowledge production. In the twentieth century mostly the private sectors' functional departments participated in the creation of high technologies. Scientific studies in the field of management provided an evidence that successful technological R&D executed in the companies where the partnership between functional departments is implemented, thus the project-oriented organization structures widely accomplished. Already in the nineteenth century, vertical disintegration was popularized and R&D activities were outsourced. B. A. Lundvall (1988) and other authors defined that these companies in many cases are interconnected, although the outsourcing of scientific and technological knowledge becomes the main strategy for many companies (Quinn, 2000), contemporarily denoted as the theory of the open innovations.

In this article, the creation of high technologies is considered as a specialized professional activity dedicated to scientific research and development. According to the United Nations industry classification system's International Standard Industrial Classification (ISIC) of all economic activities, the scientific research and development sector is assigned to the M72 division. This definition narrows the participants involved in the creation of high technologies. Moreover, there is a trend of the convergence of the scientific research and development activities into other economic activity sectors. It is particularly noticeable in the information, communication and nanobiotechnology sectors. It is empirically proved that the boundaries between these sectors are blurred (Preschitschek, Niemann, Leker, & Moehrle, 2013). Four convergence trends are distinguished: science, technologies, markets and industries. In the science activities, due to multidisciplinary disciplines, technologies overlap and new technology platforms are created, which consequently stimulate the convergence of markets (Sick, Preschitschek, Leker, & Bröring, 2018); this is especially evident in high technology sectors, where R&D activities are core, for example, electronics and pharmacy industries. In high technology sectors, short product life cycle and technological change are inherent; therefore the products are differentiated vertically while product reaches maturity and only afterwards are the technologies and products differentiated horizontally into other sectors, thus to the new markets. In these circumstances lack of knowledge about these new markets and new technologies was experienced by participants from the different sectors. This leads to various partnership forms: cooperation in R&D activities, establishment of strategic alliances or mergers and acquisitions of companies. These convergences of processes within sectors enable to develop new business models although clear boundaries of technological specialization and sectors are erased.

The exploration of the historical macro measurements' statistics indicates that till 1600–1800 the economies stagnated (Maddison, 2003); considerable economic growth was caused by the industrial revolution, although from retrospective view the attitude to the influence of technologies on economic impact varied. Neoclassicals asserted that technologies are neutral and distributed uniformly while increasing the productivity of physical and human capital (Solow, 1956). Based on this assumption the total factor productivity is evaluated in order to define the technological progress' impact on economic growth. This indicator is criticized by the post-Keynes (Domar, 2006; Harrod, 2006) and endogenous growth theory economic scientists (Romer, 1990) and new classical economics (Lucas, 1988), treating technologies as an endogenous factor; thus due to positive feedback the technologies accumulated in different countries and regions. These theories explain why some regions experience economic growth while others stagnate. The enhanced accounting methods fostered the empirical research and econometric models that define the correlations among knowledge capital, usually expressed as accumulated R&D investments and GDP with traditional capital and labour force factors. Numerous researches reveal that R&D return for society is higher than to the company that created the technology and it is valid also in international level: the productivity of one country leads to the development of other countries. But this research does not explain the technology transfer channels: trade, mobility of labour, technological alliances and so on. Since 1980s, the endogenous attitude to technologies increased with models incorporating R&D processes. In pursuance of validation of the exogenous and endogenous economic growth models, Pennsylvanian University initiated the collection of data from over 100 countries, thus named the Penn world data. The confirmation that economies of different countries converge and countries reach the stable balanced position would prove the exogenous economic growth models and in opposition the divergence would endorse endogenous models; thus for the different countries the stages of balance vary. It is empirically proved that investments to R&D and economic growth between different countries differ; thus the semi-endogenous model and another closer to reality model that encounters the factors of dynamics are proposed (Norrbin & Schlagenhauf, 1988; Fuentes & Mies, 2011).

The heterogeneity of the sectors and their strategies inherent for technology development participants (Corsaro, Cantù, & Tunisini, 2012). The triple helix model analyses differences between private, public and academic sectors participants in technology development and transfer process (Etzkowitz & Leydesdorff, 2000). Other authors analyse the heterogeneity at micro-level (Van de Ven, 2016), evaluating the internal companies' factors that impact the development of technologies; at mezzo level the differences between sectors and industrial clusters (Cohen, Nelson, & Walsh, 2003; Cooke, 2002); and at macro-level highlighting the differences between countries (Dakhli & De Clercq, 2004; Lundvall, 2007). In this article, the combination of macro and mezzo levels is proposed by comparing scientific research and development sectors' performance in different countries.

Starting from the 1980s the developed countries started to apply policies for R&D commercialization in order to get the economic return to governmental R&D investments. One of the main indicators evaluating the R&D performance in public sector is the number of patents and licenses. Most of the Organisation for Economic Co-operation and Development (OECD) countries accepted the Bayh–Dole Act principle, according to which not a government but universities and research institutions become the owners of intellectual property (Åstebro, Braguinsky, Braunerhjelm, & Broström, 2018). This performance indicator is criticized due to the narrow attitude to the role of academic sector to the impact on technology development process and also that it doesn't encounter internationalization dimensions: capital, production, knowledge or human capital movement, international partnership between universities and private sectors (Leydesdorff, Etzkowitz, & Kushnir, 2016). Despite national policy efforts, there is a tendency of accumulation of high technology sectors within global clusters, specific geographical areas, by arguing that it is caused by tacit knowledge (Pavitt, 1987).

The significant and consistent public policies designed to fund the basic research and support private R&D investments encourage numerous researches assessing the economic performance of Science and Technology Policy. Thus the efficiency and comparative advantage of R&D varies across countries due to differences in the quality of national innovation systems. In order to evaluate the performance of innovation systems and detect the problems, various indicators are developed (Dziallas & Blind, 2019). These indicators by different perspectives can be categorized into more specific factors and broad field dimensions. Innovation indicators for innovation stages are the following: the front-end indicators refer to processes from idea generation till the formal development, ex-post phase signifies innovations that are already introduced into the markets, in contrary ex-ante indicators cover early stages of the innovations. Other researches focus on indicators like direct and indirect (Becheikh, Landry, & Amara, 2006); indicators referring to science, technology and innovation indicators (Freeman, & Soete, 2009); input, throughput and output indicators (Klomp & Van Leeuwen, 2001).

The OECD Innovation Strategy recognized that it is necessary to move beyond aggregated numbers and indices for measuring the functioning of innovation systems (OECD, 2010). The traditional 'positioning' indicators are produced for policy making based on the identification of the countries on a particular issue. There is an attempt by the statistical community to develop new methods to restructure data collection in order to maximize microdata-linking opportunities and develop the 'experimental' indicators. The implementation of these incentives requires new statistical data and tools to link different data sources at an enterprise level (Nielsen, 2018).

The GVC is formatted on input–output architecture and it enables disaggregation of added value at a sectoral level, distinguishing the country origin of intermediate added value and final consumers of added value. Nowadays, with the second wave of the globalization the complexity of economic activities is increasing, and by recent estimates the exports include about 30 % of foreign inputs (OECD, 2016). The aim of the proposed comparative analysis is to position the countries' scientific research and development sectors according to the M72 sector's added value of the share of intermediate added value originating from the local country as well as the share of M72 sector's output consumed in the local economy. Although the world input–output data (WIOD) model is a dynamic and network-oriented content that enables to track the cross-border flow of added value at the sectoral level, there is an initiative within the European Statistical System to link existing data at the enterprise level and to develop the business function framework. It has to be considered that in recent decades the internationalization is a main driving force of GVC and academic literature signalling the need for more accurate and data-demanding indicators (Amador & Cabral, 2016).

Methodology for the comparative analysis of countries' involvement in the high technology creation

The proposed methodology dedicated to evaluate the country's involvement in scientific development and research of high technologies is based on WIOD database model with the sectoral level information (Timmer, Dietzenbacher, Los, Stehrer, & de Vries, 2015), where the sectors are classified according to NACE Rev.2 classification (Comissão Europeia, 2008). Section M – professional, scientific and technical activities, the division of Scientific Research and Development (M72), is depicted as the high technology knowledge-intensive service. The WIOD database enables disaggregation of added value in sectoral level by standard input–output table expressed in the matrix form (UNCAD, 2013):

$$X = T + Y \quad (1)$$

where X is the aggregated value-added matrix, T is the intermediate demand and Y is a final consumption matrix, which defines the demand of open sectors: final consumers, public sectors and non-governmental organizations, also business sectors' expenditures to the gross fixed capital formation (GFCF). T matrix columns define the share of added value in export and the rows the distribution between countries, thus the domestic value added and foreign value added can be distinguished. The added value of scientific research and development M72 sector in this article is considered as the main source of high technology knowledge creation. WIOD model is based on the System of National Accounts and from 2008 edition (Ki-moon, Strauss-Kahn, Zoellick, Gurria, & Barroso, 2009) the GFCF is treated as R&D because statistically it is difficult to separate these activities. Also, inventories are not excluded from the total value added of the sector and these assumptions lead to the limitation of the introduced comparative model (Fig. 1).

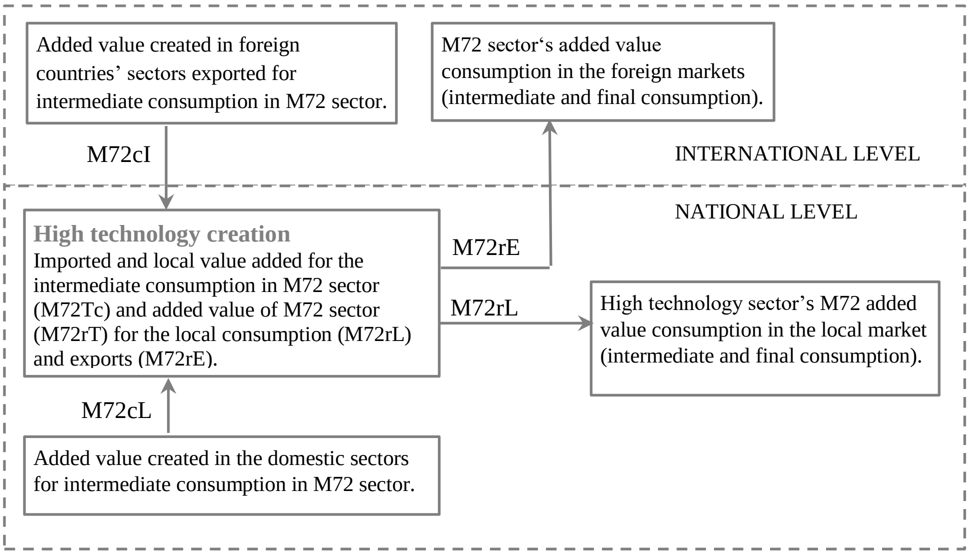

Fig. 1. High technology creation in the GVC concept (Source: author's compilation)

The creation of high technology process requires intermediate consumption (cT), with a share of intermediate consumption produced in the local market (cL) or otherwise imported. The overall output or results of the M72 sector (rT), as well as the results consumed in the domestic market (rL), includes intermediate consumption. The share of scientific development and research sector's results is used in the local market (rL) or exported. The value added of the M72 sector (M72VA) excludes intermediate consumption and this data is available in the level of the sector.

The quantitative comparative analysis of the countries' scientific research and development sector's involvement in the GVC is based on the indexes that enable to analyse and generalize complex phenomena of different size economies. In this investigation, relative aggregated values expressed in percentage will be used in order to evaluate and compare the M72 high technology domestic sector's involvement in the domestic and foreign economic activities in the context of GVC. The M72cL/M72cT indicator depicts upstream involvement into GVC processes; it indicates the share of domestic intermediate value added (M72cL) from the total intermediate value-added (M72cT) consumed in the local high technology sector. The M72rL/M72rT indicator reveals the involvement into downstream GVC processes; it indicates the share of final consumption of the domestic value added created in M72 high technology sector (M72rL) with respect to the total final consumption (rT). Based on these two indicators, countries are positioned in quadrants (Fig. 2).

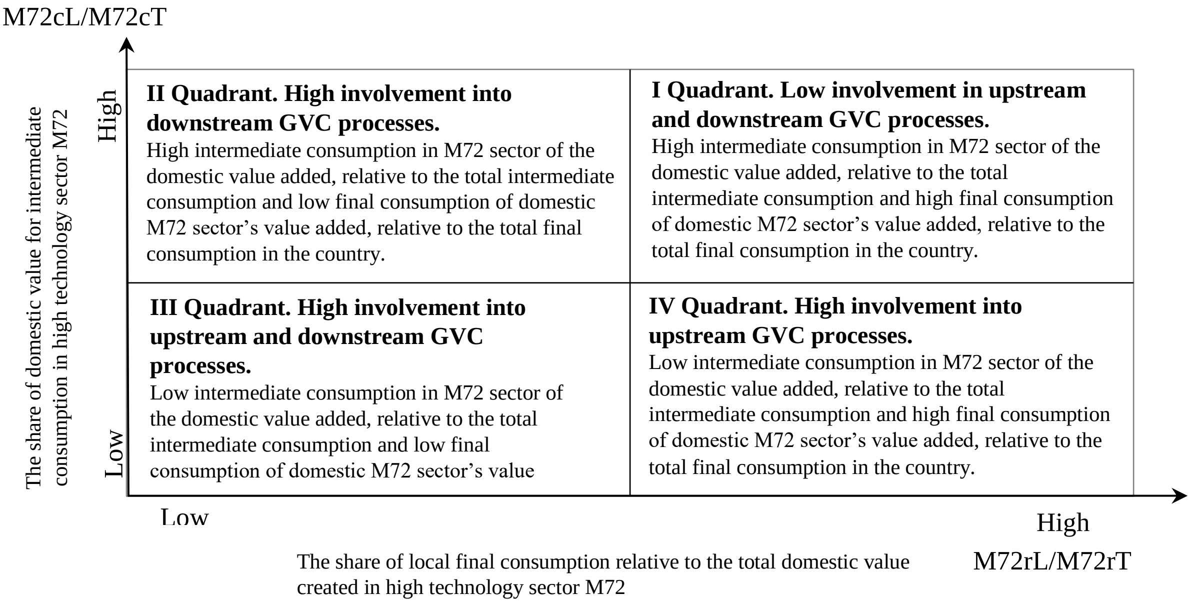

Fig. 2. The matrix concept for the comparative analysis of the sector's involvement in the GVC processes
(Source: author's compilation)

The first quadrant depicts countries where M72 sector has comparatively low involvement in GVC processes while in the domestic scientific research and development sector it consumes more than 50% of local intermediate value added relative to the total intermediate consumption (M72cL/M72cT), and the domestic final consumption of M72 high technology sector's results relative to the total output consumption in this sector (M72rL/M72rT) is more than 50%. It means that most of the M72 sector's output is absorbed in the local market for intermediate and final consumption. The second quadrant indicates countries with high involvement in downstream GVC activities of M72 sector where high technology sector consumes more than 50% of foreign intermediate total output, but less than 50% of the M72 sector's results are consumed locally and are exported for final or intermediate consumption. The third quadrant denotes high involvement in upstream and downstream GVC processes, thus there is a high foreign value-added intermediate and final consumption. The fourth quadrant positions countries that are highly involved in upstream GVC activities where more than 50% of value added for intermediate consumption in M72 sector is imported, but the M72 sector's results are consumed locally.

The WIOD is available for 43 countries and the rest of the world (RoW), but data for M72 sector's activities for Australia, Indonesia, India, Russia and Taiwan is not provided; thus the data for 38 countries is available along with the estimation for the RoW. The latest WIOD model was released with data for 2014 for the distinct economic activity sectors.

The comparative analysis positioning the countries' involvement in GVCs does not provide insight into the impact on the high technology M72 sector's performance from the national or global perspective. Therefore the linear regression model was conducted in order to define the value chain arrangement impact on value added creation of the M72 sector with respect to the overall added value of the country (M72VA/VA):

$$Y = b_0 + b_1 X_1 + b_2 X_2, \qquad (2)$$

where Y is the evaluated domestic value added in M72 sector expressed as share from the total domestic value added of all sectors in percentage (M72VA/VA) for 38 countries,

b_0 is an estimated constant,

b_1, b_2 are estimated regression coefficients,

X_1 is the share of the domestic intermediate consumption in the M72 high technology sector in percentage (M72cL/M72cT),

X_2 is the share of the consumption of domestic value created in M72 high technology sector in percentage (M72rL/M72rT).

The model was expanded by adding the main science and technology (S&T) indicators and conducted for the countries that provide data for the OECD. Only 29 countries provide information to OECD about investments to the research and development activities, number of researchers and quantity of patents. Therefore the expanded model conducted for the reduced number of countries is

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7, \quad (3)$$

where Y is the evaluated domestic value added in M72 sector expressed in share from the total domestic value added of all sectors in percentage (M72VA/VA);

$b_3, b_4\ b_5, b_6\ , b_7,$ the estimated regression coefficients;

X_1 the share of the domestic intermediate consumption in the M72 high technology sector in percentage (M72cL/M72cT);

X_2 the share of the consumption of domestic value created in M72 high technology sector in percentage (M72rL/M72rT);

X_3 the average of higher education expenditures on R&D within 3 years (HERD); X_4 the average of business expenditures on R&D within 3 years (BERD); X_5 the higher education researchers (Hres); X_6 the number of business researchers (Bres); and X_7 the quantity of triadic patents (Tpat/VA).

The values X_3, X_4, X_5, X_6 are retrieved from the OECD online database ("OECD Statistics," 2011) and are normalized to the overall value added of the country. Due to data not available for Bulgaria, Brasilia, Canada, Cyprus, Mexico, Malta, Netherlands, Romania and the United States, they are excluded from the expanded model.

Hence the aim of the linear regressions – equations 2 and 3 – is to test the null hypotheses:

1. H_0: The M72 sector's activities involvement for 38 countries and ROW in the GVC upstream and downstream processes has no impact on the high technology M72 sector's performance with respect to the value added of the overall sectors in the country (M72VA/VA);
2. H_0: The 29 countries' M72 sector's activities involvement in the GVC upstream and downstream processes, investments to R&D activities, number of researchers and quantity of triadic patents in the country have no impact on the high technology M72 sector's performance with respect to the overall sectors' value added in the country (M72VA/VA).

Comparative analysis of countries' involvement in the creation of high technologies

The absolute values of scientific research and development M72 sector highlight (Fig. 3) that the United States is the leader in generating output, and other big economy countries like France, China, Korea and Germany have more than half lower output values.

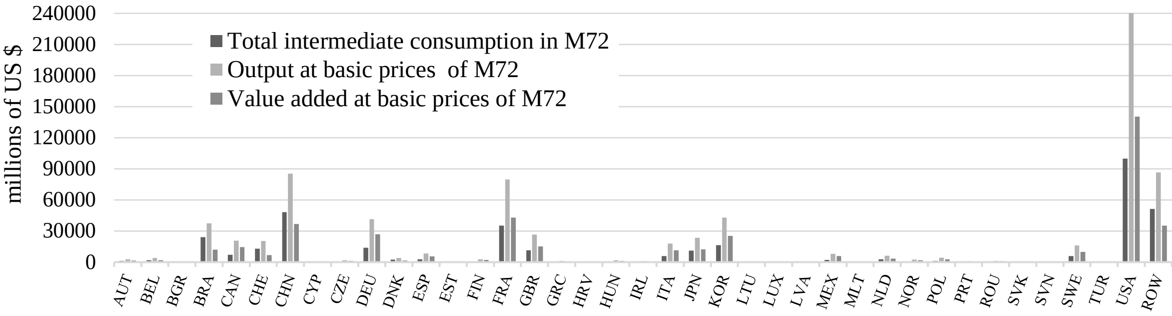

Fig. 3. Share of the intermediate consumption and value added from the total output of M72 sector
(Source: author's calculation based on WIOD (Timmer, Dietzenbacher, Los, Stehrer, & de Vries, 2015))

It can be noticed that in China, Switzerland and RoW the total intermediate consumption in the M72 sector exceeds the value added of the sector. This phenomenon is more extensively explored by expressing the share of intermediate consumption in the M72 sector and M72 sector's value added from the total output of M72 sector (Fig. 4). The intermediate consumption is weighty also in Denmark and exceeds M72 sector's added value, although Latvia, Ireland, Finland, Lithuania and Estonia have the lowest rate of intermediate consumption in the share of M72 sector's value added (M72rT). The intermediate consumption share of M72 output (M72cT/M72rT) and M72 sector's value added share of M72 output (M72VA/M72rT) indicators reflect the involvement of M72 sector in cooperation with local and foreign sectors to produce value added in the scientific research and development M72 economic activities.

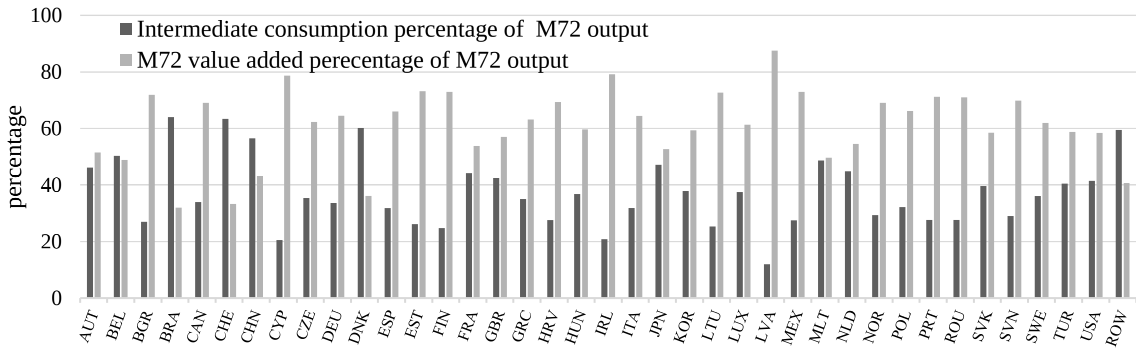

Fig. 4. Share of the intermediate consumption and value added from the total output of M72 sector
(Source: author's calculation based on WIOD (Timmer, Dietzenbacher, Los, Stehrer, & de Vries, 2015))

Based on WIOD it is estimated that the countries' M72 sector's share of added value from all sectors' global value added in 2014 is only about 0.0058%. The data about the added value of M72 sector (very low) indicates that India, Indonesia, Australia and Russia do not provide data for the M72 sector's output although the total value added of these countries are included. Therefore for better comparison of M72 sector's performance of the country in the global scale is to evaluate the ratio of M72 sector's value added of the country with respect to the M72 sector's value added of all countries (M72VA/M72GVA). The absolute leader is the United States with 32.7% of global M72 sector's value added (Fig. 5), with significantly lower outputs in France 10%, China 8.6%, Germany 6.2%, Korea 5.9%, Great Britain 3.5%, Canada 3.4% and for Japan, Brasilia and Italy about 3%.

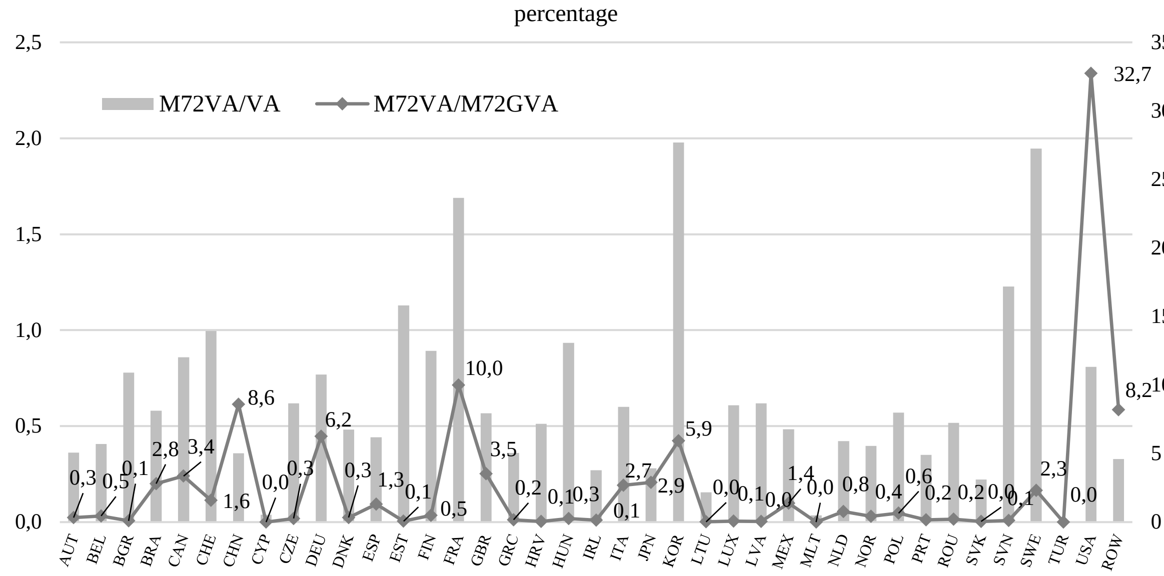

Fig. 5. Share of the intermediate consumption and value added from the total output of M72 sector
(Source: author's calculation based on WIOD, 2014)

The main reference of countries' involvement in GVC performance will be the ratio of M72 sector's added value with the overall added value of the country (M72VA/VA). This indicator reveals the most important M72 sector to be Korea, Sweden and France with about 2% of the M72 sector's share of added value from the overall value added in the country. The M72 sector's share is above 1% in small economies of Slovenia and Estonia, and for the rest of the countries, this indicator is lower.

Obviously the M72 sector's value-added share with respect to global value added of all M72 sector (M72GVA) reflects the size of the country and economy, while the M72 sector's value-added share with respect to overall value added of the country (M72VA) represents the scientific research and development sector's weight to the economy of the country.

Based on the WIOD, the matrix for positioning the countries' M72 sector's involvement in upstream and downstream GVC processes is conducted (Fig. 6). It is noticeable that most of the countries are concentrated in the II quadrant, thus in the M72 sector for intermediate consumption more than 50% of locally produced value added is consumed, but more than 50% of M72 sector's results are exported. The lowest rates of final consumption of M72 sector's results in the local markets are in Lithuania and Norway with less than 5%. In the I quadrant dominate the big economy countries, thus in the M72 sector, the intermediate consumption of domestic value added, as well as final and intermediate consumption of M72 sector's results, is exploited in the local markets. The III quadrant depicts three small economies with less than 50% of intermediate consumption in the M72 sector from the domestic added value as well as less than 50% of the final M72 sector's output consumption in the domestic market.

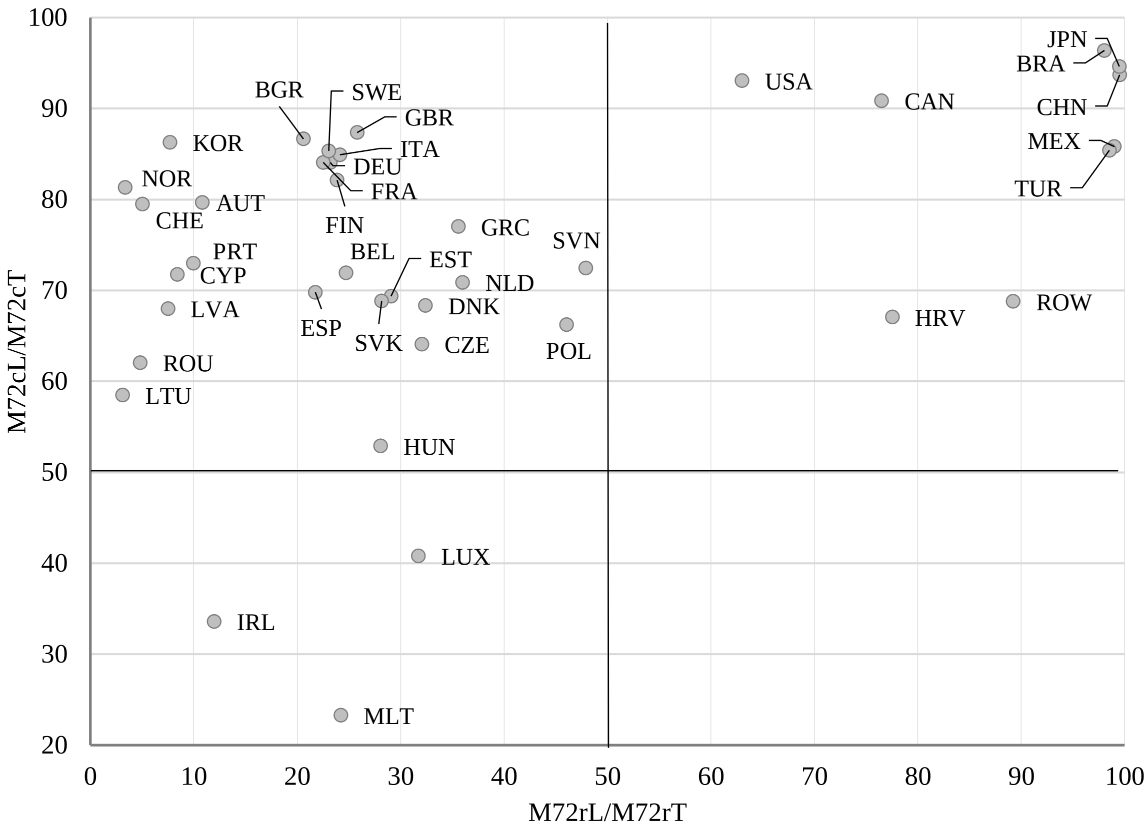

Fig. 6. The matrix for the comparative analysis of countries' M72 sector's upstream and downstream processes involvement in the global value chain (Source: author's calculation based on WIOD (Timmer, Dietzenbacher, Los, Stehrer, & de Vries, 2015))

The positioning of the countries' involvement in the GVC pattern highlights the peculiarity of the scientific research and development sector in different countries but does not indicate how this arrangement in GVC impacts this sector's performance. For that purpose, the linear regression model was developed and the share of value added of M72 (M72VA) sector from the total value added of the country (TVA) is chosen as the independent variable (Eq. 2). This indicator, denoted as M72VA/TVA, reveals the significance of scientific research and development sector within the domestic economy. The dependent variable then indicates the sector's involvement in the GVC pattern: involvement in upstream GVC processes or share of local output for intermediate consumption in M72 sector (M72cL/M72cT) and involvement in downstream GVC processes or the share of local intermediate and final consumption of M72 sector's results (M72rL/M72rT). The linear regression modelling was performed with the SPSS software. The result of the adjusted determination coefficient is equal to $R^2 = 0.382$, therefore the regressors fit the model, although $p = 0.251$ for the M72rL/M72rT value and $p = 0.018$ for the M72cL/M72cT indicate that only the regressor of intermediate consumption in the M72 sector is statistically significant. The regressors do not have multicollinearity because variable inflation factor for both regressors is VIF =1.171 and differences in beta show that the data has no outliers although the normality test for the distribution of standardized residuals does not indicate that data is normally distributed.

The second model (Eq. 3) was expanded by introducing new independent variables although the data about the investments to scientific research and development, number of researchers in private and public sector or number of the triadic patents are not available for nine countries and RoW. Calculated linear regression model determination coefficient is equal to $R^2 = 0.512$, therefore the additional regressors better define the model. Coefficients values (Table 1) indicate that regressor M72cL/M72cT is not significant and regressor M72rL/M72rT is significant. When comparing coefficients values of the linear regression model in the case with 38 countries and RoW, the significances differ. Thus in the case with all available countries the share of local intermediate consumption (M72cL/M72cT) is significant for the results of M72 sector's performance and vice versa, but in the model with 28 countries the significant coefficient is M72rL/M72rT, but the coefficient value is negative. Therefore it could be concluded that in countries with higher share of M72 sector's value-added consumption locally, the M72 sector's performance is lower. This diversity of the significance and coefficient values in different linear regression models presumes that countries should be clustered by the size of the economy, regions or other factors. Another significant coefficient value in the model is BERD, in contrary to HERD. This result confirms other scientific research results that the business investment in M72 sector is the most significant factor for the high technology sector's performance. The model's VIF value is lower than 4; this model's independent variables does not face multicollinearity problem and the test of normality for standardized residuals does not reject the hypothesis of data normal distribution.

Table 1. Linear regression model coefficients values (Source: author's compilation)

	Unstand. Coefficients		Stand. Coef.			Collinearity Statistics	
	B	**Std. Error**	**Beta**	***t***	**Sig.**	**Tolerance**	**VIF**
(Constant)	–0.087	0.512		0.170	0.867		
M72cL/M72cT	0.006	0.007	0.165	0.881	0.389	0.694	1.441
M72rL/M72rT	–0.009	0.003	–0.461	–2.666	0.015	0.817	1.224
HERD/VA	0.199	0.494	0.081	0.404	0.691	0.604	1.656
BERD/VA	0.311	0.148	0.511	2.104	0.048	0.413	2.419
Hres/VA	–0.043	0.043	–0.251	–1.000	0.329	0.386	2.592
Bres/VA	0.071	0.071	0.218	1.003	0.328	0.518	1.932
Tpat/VA	–0.267	1.471	–0.045	–0.182	0.858	0.406	2.463

Dependent variable: M72VA/TVA share of M72 VA from TVA

The regression model was composed to show the dependent variable M72VA/VA's performance from two significant independent variables, M72rL/M72rT and BERD/VA. Then the determination coefficient is a bit lower $R^2 = 0.456$ but the significance of regressors is slightly increased (Table 2).

Table 2. A linear regression model with significant coefficients values (Source: author's compilation)

	Unstand. Coefficients		Stand. Coef.			Collinearity Statistics	
	B	**Std. Error**	**Beta**	***t***	**Sig.**	**Tolerance**	**VIF**
(Constant)	0.398	0.155		2.571	0.061		
M72rL/M72rT	–0.008	0.003	–0.399	–2.647	0.014	0.957	1.045
BERD/VA	0.385	0.092	0.634	4.203	0.000	0.957	1.045

Dependent variable: M72VA/TVA share of M72 VA from TVA

In the model there is no multicollinearity of independent variables and the test of normality of residuals does not reject the hypothesis of data normal distribution. Then the final regression model is

$$Y = 0.398 - 0.008X_2 + 0.385X_4, \tag{4}$$

where Y is the evaluated domestic value added in M72 sector expressed in share from the total domestic value added of all sectors in percentage (M72VA/rVA); X_2 the share of the consumption of domestic value created in M72 high technology sector in percentage (M72rL/M72rT); and X_4 the share of business expenditures on R&D (HERD/VA) from the overall added value of the country. The standardized coefficient beta for BERD/VA is 0.634 and for M72rL/M72rT is -0.399, thus the investments of business in scientific research and development have almost double higher influence than exports of M72 sector's value added.

The negative sign of the indicator M72rL/M72rT implies that final consumption of the domestic total output leads to lower share of total value added of M72 sector from the total value added of the country (M72VA/TVA). This imposes that higher involvement to the downstream GVCs could lead to higher significance of M72 sector at national economy. Not all of value added of M72 sector consumed domestically is encountered by the variable M72rL. The domestic expenditures on GFCF and inventories are not included. GFCF doesn't necessary indicates expenditures on fixed assets while from 2008 by System of National Accounts standard it also embraces the investments to R&D. The inventories reveal the consumption of value added that was produced and accumulated in other than the current year, therefore it is also omitted from the local consumption of M72 sector's results. The proposition for future investigation is to introduce separate indicators for the domestic intermediate and final consumption as well as GFCF and inventories. In this case the methodology for the positioning countries for evaluating involvement in GVC could be expanded for various factors: domestic intermediate consumption, domestic government and non-profit organization final consumption, domestic final household consumption, investments to GFCF and consumption of inventories. The gross domestic consumption of M72 sector's results should encounter all these expenditures to represent the overall level of involvement to the downstream GVCs. The GFCF could be an appropriate indicator for the creation of technologies within companies considering that investments to the R&D are treated as investments that generate long-run added value, although the constraint due to mutually accounted fixed assets should be encountered.

Conclusions

This research is focused on the scientific research and development sector M72 as the main specialized economic activity dedicated to the high technology creation. The vast investigations are devoted to evaluating R&D investments and technologies impacting the economic performance of the country. The global competitive environment in high technology sectors encouraged to comprehensively investigate the scientific research and development M72 sector's involvement in the upstream and downstream GVC by deriving new factors that may trigger the performance of the M72 sector. The WIOD enables to disaggregate domestic and foreign added value flow at a sectoral level within 43 countries and RoW. Despite the limitations of the sectoral level data the comparative analysis of the M72 sector's involvement in GVC pattern indicates that most of the developed countries do not use intensively M72 sector's added value for final and intermediate consumption. These different patterns of the M72 sector's involvement in GVC should be investigated further to understand the nature of high technology creation and to strengthen a country's competitive position in the GVCs.

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