THE UNEMPLOYMENT RATE AND INNOVATIVE ACTIVITY: A CROSS-COUNTRY ANALYSIS

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Abstract:

The aim of this study was to analyze how the relation between unemployment and innovation activity can affect the productivity of the economy through its impact on the export structure. The results of research carried out on a group of 69 countries in the years 1996-2016 indicate that the nature of the relationship between the unemployment rate and innovation activity may affect both positive and negative changes in the technological sophistication production structure and thus exports. In our study also occurs a two-way relationship between the increase in expenditure on R&D activity and the decline in the unemployment rate. This means that the decrease in the unemployment rate may impact the growth of innovation activity, which in turn generates a further decline in the unemployment rate. In line with expectations, this is more typical for higher-income countries, already possessing a sufficiently developed economic structure and a well-functioning labor market.

Keywords: unemployment rate, innovation activity, export structure.

JEL Codes: E24, J01.
DOI: 10.19197/tbr.v17i4.305

1. Introduction

In the case of a relative high unemployment rate, there may be a decrease in the propensity to take innovative actions that will cause the negative changes in the production structure in the economy and therefore export. Hence, the aim of this study is to analyze how the relationship between unemployment and innovation activity can affect the productivity of the economy through its impact on the export structure.

The paper is organized in the fallowing way. The first part presents the possible connections of unemployment, innovation activity, and technological progress expressed in the export structure of the country in the light of the economic development theory. For this purpose, relevant literature has been analysed.

The second part is to illustrate the mentioned theoretical connections in the first part. Based on the data sets of international institutions such as the United Nations Educational, Scientific and Cultural Organization (UNESCO), the International Labor Organization (ILO), the United Nations Conference on Trade and Development (UNCTAD), and the World Bank (WB) the relationships among variables of unemployment, innovation activity, and export structure are analyzed. Therefore, this part describes the methodological assumptions, the materials and the results of own research conducted on a group of 69 countries in the years 1996-2016.

2. Theoretical background

The labor markets of least developed, developing and developed countries are not the same in the structures, attitudes to work and ways of acting. In these groups of economies, the methods of combating unemployment, education in the field of work and preparation for professions are different. That is why we don’t have the one ready recipe to make the labor market work better.

The unemployment rate is usually seen as an indicator of the efficiency of an economy to absorb the labor force. Although the official unemployment rates may be low in developing countries, it is important to remember that the shares of population engaged in the informal economy tend to be high. As the ILO explains, countries where there is no a safety net of unemployment insurance and welfare benefits, many individuals, despite strong family solidarity, simply cannot afford to be unemployed. In this way they often find work in the informal economy or in informal work arrangements. However, informal employment rates tend to decrease as economic development continues but remain high in most developing countries (Bacchetta et al., 2009; ILO, 2013; ILO, 2018).

Passing on to next stages of economic development is closely related to an increase in the share of low-, medium- and high-skill intensive products and a decline in the share of primary goods as well as labor- and resource-intensive manufactures. At the beginning of economic development countries have the majority of their advantages in natural resources, and the export sector consists mostly of labor-intensive manufacturing, such as agricultural and primary goods. For example, some researchers indicate that the main aim of the labor market policy in developing countries with high unemployment should be initially the labor-intensive growth. This policy focuses mainly on creation large-scale job and developing skills in work. Thanks to this policy, the labor force can transform from unskilled to be able to perform more and more complex tasks in the formal economy (Zhang, Yang, & Wang, 2011, Jantoń-Drozdowska, & Majewska, 2013; Nattrass & Seeking, 2018).

Thanks to advances in hard infrastructure and education, industrializing economies are beginning to shift towards capital-intensive sectors and slightly more sophisticated and knowledge-intensive goods (e.g., electrical products, clothing, processed foods). As countries want to develop to produce more sophisticated products that require suitability qualificated workers, more emphasis is put on innovation activities, development of skills related to human capital, and soft infrastructure. This will be reflected, among other things, in higher expenditures on innovation activities.

The last stage of economic development is characterized by comparative advantage in high-skill and technology-intensive manufactures and knowledge workers. Hence, as many researchers suggest, technological progress usually reduces the number of existing jobs with low skills and knowledge requirements, and contributes to the creation of new jobs with higher skills and knowledge requirements (Narula, Dunning, 2000; Dunning, Kim, Lin 2001; Ferencikova, Ferencikova 2012; Stoian 2013 pp. 615-637; Aguilera & Ramos Barbera, 2016; Jantoń-Drozdowska & Majewska, 2016; WTO, 2017, 76-100; Přívara & Přívarová, 2018).

High wages, justified by improving productivity, may indicate an increase in income of a given economy, while low wages can may indicate low national competitiveness. In other words, the wages level can either reduced or support technological progress. In the conditions of technological progress, e.g. automation, robotics, smart technology, artificial intelligence, employees who want to expand their knowledge and skills may see their earnings increase significantly in the future which will encourages them to continue their learning. On the other hand, as low labor costs remain the base of production profitability, employees' knowledge and skills are getting older, because entrepreneurs do not want to invest in the quality of human capital. In this situation wages and technological capabilities suppressed by labor-intensive technology steadily eroding the value of work and labor productivity (Jung & Mercenier, 2014; WTO, 2017, 76-100; WEF, 2018, 10-14).

The risk of decreasing propensity to invest in technological progress may be deepen by low wages. Especially in relatively high surplus labor, entrepreneurs may understate wages as compared to the increase in productivity of human capital. As recalled Baffoe-Bonnie and Gyapong (2012) in the traditional growth theory an increase in the unemployment rate reduces the rate of wage growth, and productivity growth drives wage growth. In other words, we can have a desired situation in the labor market, because wages are strongly related to employee productivity. In reality, however, wages may increase faster or slower than productivity for various reasons and the bases of rewarding systems may constitute such factors as nepotism, fawning, and various negative connections between individuals (WEF, 2006, 30-105; Tantardini & Garcia-Zamor, 2015).

In summary, even in developed economies, low wages increasing slower than productivity may imply the adoption of labor intensive technologies instead of implementation of more capital and knowledge intensive technologies in the manufacturing process. Employers, who prefer discounting labor-cost comparative advantage, usually do not want to introduce either labor-saving innovations or labor-augmenting

technology which slows down economic development. Ultimately, the above dependencies are reflected in the structure of production in the economy (hence export structure), in which the less technologically advanced sectors dominate.

3. Methodology of research

Data on research and development (R&D) came from the UNESCO; on unemployment rates from ILOSTAT; on GDP*pc* and export structures from the UNCTAD statistics. We choose the size of gross domestic expenditure on R&D per capita in purchasing power parity on the indirect measure of a country's innovation activity – GERD*pc*. Unemployment rates presented in ILOSTAT are calculated by expressing the number of unemployed persons as a percentage of the total number of persons in the labor force - UNRate. In our study the labor force was defined as all persons employed and unemployed aged 15 and older. Here, GDP per capita, expressed in current prices denominated in USD, was treated as an indirect index of national wealth - GDP*pc*.

As it was described, the outcomes of innovation activity of a given country can be observed in the changes of its export structure. Thus, in the study of the segmentation criterion of trade structure is the degree of technological sophistication. Using the UNCTAD data the authors calculated the percentages of the following categories of product in the export structure of each country:

1. Primary commodities, precious stones and non-monetary gold (EXPPC);
2. Manufactured goods by degree of manufacturing:
   - Labor-intensive and resource-intensive manufactures (EXPLRM);
   - Low-skill and technology-intensive manufactures (EXPLSM);
   - Medium-skill and technology-intensive manufactures (EXPMSM);
   - High-skill and technology-intensive manufactures (EXPHSM).

Due to the availability of UNESCO data on innovative activities it was decided to include 69 economies. The

analysed economies were divided in two groups according to the World Bank's classification of countries by income. The Wold Bank divides economies using gross national income (GNI) per capita into four income groups: low, lower-middle, upper-middle, and high. For 2016, which was the last year of the research period, according to the WB low-income economies were those with a GNI per capita of less than $ 1,045; lower-middle of less than $4,125; upper-middle of less than $12,736. In our study the first group consisted of 33 economies with low and lower middle income status, classified as lower-income economies. The second group includes 36 countries with upper-middle and high incomes, classified as higher-income economies.

A decision was made to apply the Pearson linear correlation method and regression analysis. In this case the variation of unemployment rates and export groups was expressed as a percentage. The GERD*pc* and GDP*pc* variables have been transformed into natural logarithms. The next method was Spearman's rank correlation which is used to measure the strength and direction of linking two variables in the ranking. Therefore, the examined economies were separately put in accordance with all variables included in the study and then numbered.

In the case of GDP*pc* and GERD*pc*, the economies were ranked in descending order. As a result, the countries with the highest of GDP*pc* and GERD*pc* levels topped the list. The ascending order was used for unemployment rates and export groups. In this order the sportiness begins with the smallest or lowest value and moves to the largest or highest value. This means that the economies with the lower values of unemployment rates and export categories of product occupied higher positions in a given ranking.

The analysis of correlation and regression also took into account time delays in which the independent variable either being the unemployment rate or gross domestic expenditure on R&D in year t_0, is the cause of the emergence of the phenomenon being explained in year t_{-1} and t_{-2}. In other words, models that take into account time delays allow to check if there is a statistically significant dependence of one variables on the other variable.

The cluster analysis also was performed, as it allowed us to examine the similarities and dissimilarities between groups of countries. The cluster analysis was carried out using the agglomeration method based on 1-r Pearson measure of distance for the features of two groups of economies divided according to their income level. The results of our analysis should show which clusters of variables were more typical for studied groups of economies in the years 1996-2016. The results of the cluster analysis are presented graphically in a dendrogram whose branches represent distances between variables.

3. Research results

Before discussing the results of correlation analysis with panel data, it is worth recalling that the interpretation differs according to the number of observations. For smaller samples correlation coefficients can be high and not statistical significant, and for larger samples low and significant. In our research, the number of observations reported in the following tables ranges from 590 to 1325.

The interdependency between an increase in the unemployment rate and a lower scale of gross domestic expenditure per capita on R&D has been confirmed by Pearson’s linear correlation analysis for a whole set of countries (Table 1). The same results were obtained using Spearman's rank correlation method between the positions of test countries in rankings of the unemployment rate and R&D per capita. A positive value of Spearman’s correlation coefficient means that the ranks of both the variables are increasing. Thus, as a test country improves its position in the ranking of the descending unemployment rate among all surveyed countries, it also advances its position in the ranking of rising expenditure on R&D activity. The statistically significant relationship between these variables persists over time and is two-way directional. The above relationship between the UNRate and GERD*pc* is reflected in the negative dependence of GDP *pc* on the unemployment rate.

Pearson’s correlation coefficients are statistical significant for the relationship between the unemployment rate and EXPLRM, EXPLSM, EXPMSM, and EXPHSM. The coefficients for the EXPLRM and EXPLSM dependence on the un-

employment rate are positive, whereas in the case of EXPMSM and EXPHSM this dependence is negative. The strongest Pearson's correlation occurs in export of low-skill and technology-intensive, moderate in labor-intensive and resource-intensive exports, weak in medium-skill and technology-intensive exports, and none in primary commodities, precious stones and non-monetary gold exports. Therefore, we can assume that the UNRate grows the percentage shares of EXPMSM and EXPHSM has probably decreased in the favor of increasing shares of EXPLRM and EXPLSM in the overall export structure.

Table 1. Correlation coefficients for relationship between unemployment rate, expenditure on R&D in PPP, export groups in % and GD*P pc*, 1995-2016

Dependent Variable	**Independent variables – t_0 Number of observations: N_{t0} =1325, Nn_{t-1} =1325, Nn_{t-2} =1160**						
	GERD *pc*	**EXPPC**	**EX-PLRM**	**EXPLSM**	**EXPMSM**	**EXPHSM**	**GDP *pc***
	Pearson's correlation						
UNRate t_0	-0.19*	0.02	0.17*	0.30*	-0.08*	-0.23*	-0.17*
UNRate t_{-1}	-0.19*	0.02	0.17*	0.29*	-0.08*	-0.23*	-0.18*
UNRRate t_{-2}	-0.21*	0.04	0.17*	0.31*	-0.09*	-0.25*	-0.19*
	Spearman's rank correlation						
UNRate t_0	0.16*	0.11*	0.19*	0.22*	-0.02	-0.20*	0.24*
UNRate t_{-1}	0.16*	0.11*	0.19*	0.21*	-0.03	-0.20*	0.24*
UNRRate t_{-2}	0.18*	0.17*	0.19*	0.21*	-0.03	-0.21*	0.24*

Dependent Variable	Independent variables – t_0 Number of observations: N_{t0}=1325, Nn_{t-1}=1269, Nn_{t-2}=1206						
	UNRate	**EXPPC**	**EX-PLRM**	**EX-PLSM**	**EXPMSM**	**EXPHSM**	**GDP *pc***
	Pearson's correlation						
GERD *pc* t_0	-0.19*	-0.47*	-0.28*	0.10*	0.54*	0.52*	0.89*
GERD *pc* t_{-1}	-0.18*	-0.49*	-0.27*	0.10*	0.54*	0.52*	0.88*
GERD *pc* t_{-2}	-0.17*	-0.49*	-0.28*	0.10*	0.53*	0.51*	0.88*
	Spearman's rank correlation						
GERD *pc* t_0	0.16*	0.36*	0.16*	-0.18*	-0.53*	-0.56*	0.82*
GERD *pc* t_{-1}	0.21*	0.39*	0.15*	-0.17*	-0.53*	-0.55*	0.82*
GERD *pc* t_{-2}	0.14*	0.37*	0.15*	-0.19*	-0.52*	-0.54*	0.81*

Note: * coefficients statistically significant on the level 0.05.
Source: own calculation.

The estimated Spearman's rang coefficients presented here confirmed the results obtained with the help of Pearson's correlation analysis. Recalling in these 5 rankings countries were ranked in ascending order, and in the case of export groups countries were sort according to their percentage shares. The results of Spearman's rank correlation signify that as the rank of the unemployment rate is rises, the ranks of medium and high-skill and technology-intensive exports decrease, but only for EXPHSM the coefficient is statistically significant. The positive correlation between the unemployment rate and the shares of EXPPC, EXPLRM, and EXPLSM means that all ranks of these variables

are increasing. The position of test countries according to the unemployment rate is strongly correlated with places they occupied of EXPLRM, EXPLSM and EXPHSM rankings, medium for EXPPC, and none for EXPMSM. Thus, the results of our correlation analysis suggest that a decrease or an increase in the unemployment rate can cause negative or positive changes in the export structure divided according to the level of technological sophistication.

In terms of data collected the results of correlation analysis performed out for the relationship between R&D expenditures, export groups, and GDP *pc* are consistent with the economic development theory and thus indirectly strengthen the results regarding the impact of the unemployment rate. All correlation coefficients are statistically significant. Signals of coefficients indicate that the higher proxy of innovation activity, the larger shares of low, medium and high-skill and technology intensive exports, the lower shares of labor-intensive and resource-intensive exports and primary commodities, precious stones and non-monetary gold exports. The changes in the GERD *pc* had the strongest impact on the medium and high-skill and technology-intensive manufactures and primary commodities, precious stones and non-monetary gold exports, moderate on labor-intensive and resource-intensive manufactures, and the weakest on low-skill and technology-intensive manufactures. The strongest correlation relation occurred between an increase of expenditure on R&D and a rise of GDP *pc.* Moreover, this positive influence of GERD *pc* on export structure and GDP *pc* continues over time and is interconnected with each other.

Table 2 presents the parameters of regression equations which were estimated only for statistically significant correlation coefficients for the dependence of expenditure on R&D, export groups and GDP *pc* on the unemployment rate. The results show that the parameters of the variables have kept the expected signals and they are statistically significant. Thus in the empirical regression models, the expected negative relationship between the unemployment rate and the proxy of innovation activity was confirmed. In additionally, the magnitudes of regression coefficients indicate the strength and dynamics of the impact of the independent

variable on dependent variables over time.

The magnitudes of regression coefficients suggest that among all export groups the share of high-skill and technology-intensive exports is changing at the most accelerated pace in response to the increase or decrease in the unemployment rate. Remembering that this type of export was the strongest correlated with the R&D activity, we can assume that the outcomes of decreasing unemployment rate in the form of higher expenditure on innovative activities should be directed to the development of industries employing more knowledge workers. Eventually this will be reflected in the acceleration of technological progress and thus will lead to the growth of national wealth. It also explains why in our study the impact of an increase in the unemployment rate on a decrease in GERD *pc* and GDP *pc* are visible much later than in the case of EXPLRM, EXPLSM and EXPHSM – in other words in long term.

Table 2. Results of regression analysis for relationship between unemployment rate, expenditure on R&D, export groups and GD*P pc*, **1995-2016**

	Regression Coefficient	**Constant**	R^2	**F**	**p-value**
Dependent variables	**Independent variables**				
	UNRate $_{t0}$				
GERD *pc* $_{t0}$	-0.0571* (0.0083)	5.2579* (0.0847)	0.0348	47.673	0.0000
EXPLRM $_{t0}$	0.3489* (0.0656)	11.6232* (0.6736)	0.0192	28.301	0.0000
EXPLSM $_{t0}$	0.3140* (0.0293)	5.1876* (0.3007)	0.0737	115.06	0.0000
EXPHSM $_{t0}$	-0.6336* (0.0705)	25.9734* (0.7239)	0.0529	80.820	0.0000
GDP *pc* $_{t0}$	-0.0465* (0.0065)	9.5071* (0.0666)	0.0344	51.487	0.0000
	UNRate $_{t-1}$				
GERD $_{t0}$	-0.0571* (0.0082)	5.2631* (0.0848)	0.0354	48.514	0.0000
EXPLRM $_{t0}$	0.3197* (0.0654)	11.8560* (0.6760)	0.0162	23.877	0.0000
EXPLSM	0.3116*	5.1899*	0.07	114.	0.0000

$_{t0}$	(0.0292)	(0.3014)	31	14	
EXPHSM $_{t0}$	-0.6294* (0.0702)	25.9743* (0.7254)	0.05 26	80.3 56	0.0000
GDP *pc* $_{t0}$	-0.0453* (0.0065)	9.4993* (0.0668)	0.03 28	49.1 39	0.0000
	UNRate $_{t-2}$				
GERD $_{t0}$	-0.0637* (0.0087)	5,2788* (0,0900)	0.04 42	53.5 45	0.0000
EXPLRM $_{t0}$	0,3284* (0,0623)	10,9003* (0,6432)	0.02 20	27.8 18	0.0000
EXPLSM $_{t0}$	0,3412* (0,0324)	5,0863* (0,3349)	0.08 21	110. 75	0.0000
EXPHSM $_{t0}$	-0,6944* (0,0768)	26,5554* (0,7934)	0.06 19	81.7 42	0.0000
GDP *pc* $_{t0}$	-0,0497* (0,0071)	9,5237* (0,0730)	0.03 85	49.5 91	0.0000

*statistically significant coefficient and constant on the level 0.05.
Source: own calculations.

The results from the estimated models of dependencies between the unemployment rate and the proxy of innovation activity, presented in Table 3, indicate that Pearson's and Spearman's correlation coefficients are only statistically significant for higher-income economies. The negative signals of Pearson's and the positive of Spearman's rank coefficients for the dependence of GERD *pc* on the unemployment rate signify that the higher unemployment rates, a smaller proxy of innovation activity and the bigger fall in countries' ranking by R&D. In the case of lower-income economies, the lack of a statistically significant relationship between these variables probably results from too low expenditures on R&D and the unformatted yet formal labor market.

Table 3. Correlation coefficients for the dependence of expenditure on R&D, export groups and GD*P pc* on unemployment rate, 1995-2016

	Lower-income economies **Number of observations: N_{t0} =608, Nn_{t-1} =608, Nn_{t-2} =590**

	GERD *pc*	**EXPPC**	**EX-PLRM**	**EX-PLSM**	**EXPMSM**	**EXPHSM**	**GDP *pc***
	Pearson's correlation						
UNRate t_0	0.03	-0.04	0.11*	0.36*	-0.10*	-0.20*	0.12*
UNRate t_{-1}	0.04	-0.03	0.09*	0.37*	-0.10*	-0.20*	0.14*
UNRRate t_{-2}	0.04	-0.03	0.11*	0.36*	-0.09*	-0.20*	0.15*
	Spearman's rank correlation						
UNRate t_0	-0.05	0.10*	0.00	0.25*	-0.07	-0.14*	-0.17*
UNRate t_{-1}	-0.06	0.08*	0.00	0.26*	-0.07	-0.13*	-0.17*
UNRRate t_{-2}	-0.05	0.10*	0.00	0.25*	-0.07	-0.14*	-0.17*
	Higher-income economies Number of observations: N_{t0} =717, Nn_{t-1} =717, Nn_{t-2} =691						
	GERD*pc*	**EXPPC**	**EX-PLRM**	**EX-PLSM**	**EXPMSM**	**EXPHSM**	**GDP*pc***
	Pearson's correlation						
UNRate t_0	-0.28*	-0.08*	0.23*	0.13*	0.08*	-0.17*	-0.45*
UNRate t_{-1}	-0.30*	-0.08*	0.24*	0.12*	0.08*	-0.17*	-0.48*
UNRRate t_{-2}	-0.29*	-0.08*	0.22*	0.12*	0.10*	-0.17*	-0.48*
	Spearman's rank correlation						
UNRate t_0	0.23*	0.04	0.42*	0.25*	0.15*	-0.13*	0.51*
UNRate t_{-1}	0.24*	0.04	0.41*	0.24*	0.15*	-0.13*	0.53*
UNRRate t_{-2}	0.24*	0.05	0.40*	0.24*	0.16*	-0.13*	0.54*

*statistically significant coefficient and constant on the level 0.05.
Source: own calculations.

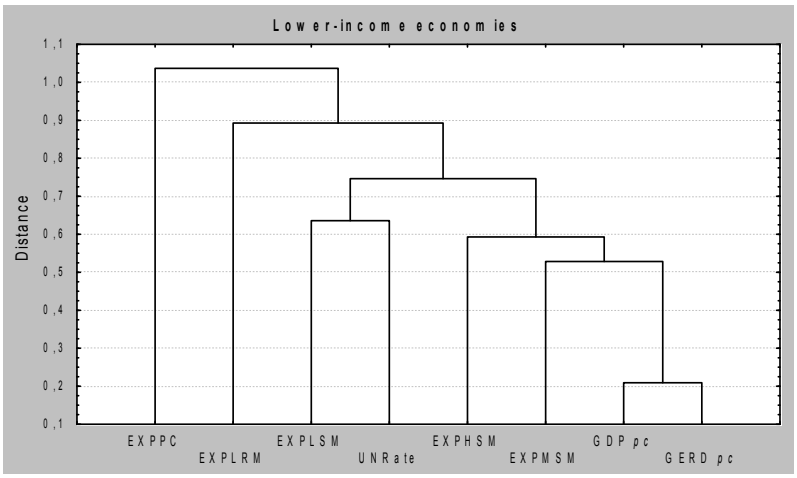
Statistically significant results of Pearson's correlation analysis performed for the relationship between the unemployment rate and GDP *pc* show that in the group of lower-income economies this relationship is positive in contrast to the group of higher-income economies. These dependences confirm Spearman's rank coefficients. They indicate that with the rank of the unemployment rate of a given higher-income economy was increasing (lower UNRate), the positions occupied by this country in the ranking of GDP *pc* was advancing (higher size of GDP*pc*). The opposite situation occurred in the case of lower-income economies.

Pearson' correlation analysis shows that in both groups of economies changes in unemployment rate had the statistically significant influence on all categories of exports with the exception of primary commodities, precious stones and non-monetary gold. For both groups of economies, the positive coefficients occurred for the relations between the unemployment rates and labor-intensive and resource-intensive as well as low-skill and technology-intensive exports. However, in the case of lower-income economies the correlation coefficients were three times higher for EXPLSM than for EXPLRM, while in higher-income economies they were two times lower for EXPLSM than for EXPLRM. In the case of medium-skill and technology-intensive exports the correlation coefficients occurred positive for lower-income economies, and negative for higher-income economies, but they were of similar strength. In both groups of economies, the dependence of medium-skill and technology-intensive exports on the unemployment rates was negative and had similar magnitude.

Spearman's rank correlation coefficients calculated for lower-income countries indicate that as the rank of the unemployment rate of a given country increases (lower UNRate), the position occupied by this country in the ranking of EXPHSM drops (higher share in export structure). The reverse correlation relation occurred for EXPPC and EXPLSM. Spearman's rank correlation coefficients are not statistically significant for EXPLRM and EXPMSM. In this group of economies, the strongest correlation relation was between the unemployment rate and EXPLSM.

Estimated Spearman's rank correlation coefficients for higher-income economies indicate that a drop in the unemployment rate ranking (higher UNRate) implies an advance in the EXPHSM ranking (lower share in export structure). The opposite situation occurred in the case of EXPLRM, EXPLSM, and EXPMSM. The Spearman's rank correlation relationship is not statistically significant for EXPPC. Here the size of Spearman's rank coefficient was the highest for EXPLRM.

Thus, the study's finding carried out for the relationship between the values or ranks of UNRate and export groups confirm that the unemployment rate impacts the pattern of export structure differently, depending on how developed country is.



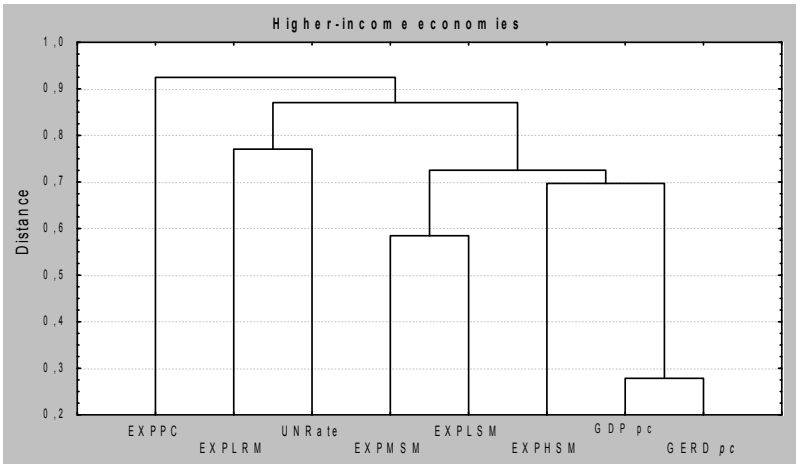


Figure 1. Dendrogram for selected variables of surveyed countries clustered using 1-rPerason Distance, 1996-2016
Source: own work.

The dendograms, shown in Figure 1, illustrates which clusters have been joined at each stage of the analysis and the distance between clusters for two groups of economies with lower or higher level of income. In two groups of analyzed economies the shortest distances between expenditure on R&D and GDP *pc* is observed which indicates the importance of innovation activity in the process of increasing the country's prosperity.

The lower-income economies display main cluster contained expenditure on GDP *pc,* medium and high-skill and technology-intensive manufactures. But in this group of economies, EXPMSM is more strongly correlated with variables describing the country's productivity that is GERD *pc* and GDP *pc* compared to higher-income economies. This is due to the lower level of technological capabilities occurring at the first stages of the country development path. Technological capabilities are usually understood as a capacity to generate new knowledge and use of knowledge already developed to implement a technological change. In other words, they are mainly the capabilities that concern a broadly defined innovation activity. They shape better conditions for a technological progress, e.g. human capitals skills, education systems, information and communication infrastructure, technological intensive factors of production such

as machines, devices and laboratory equipment. Among technological capabilities indicators are the expenditures on R&D (Sears & Hoetker, 2014; Lis & Majewska, 2016).

In similar node the second cluster between the unemployment rate and low-skill and technology-intensive manufactures joins to the main four elements cluster. These two clusters are relatively close together. The results of cluster analysis confirm therefore the strongest correlation relationship between the unemployed rate and low-skill and technology-intensive manufactures estimated for lower-income economies. The longest distances in relation to other examined features of lower-income economies occurred in the case of labor-intensive and resource-intensive manufactures and primary commodities, precious stones and non-monetary gold. This implies that these two variables were relatively far apart from other examined variables. Additionally, in this group of economies more variables are closer in terms of distances between them compared to higher-income economies. This indicates that in the group of lower-income economies the examined variables may influence one another more strongly. In other words, smaller changes cause higher effects, which again is associated with a lower level of economic development. In the case of advanced economies current technologies do not have the same productivity-enhancing potential as inventions of the past, and their effects are visible in a longer period than in lower-income countries (Jantoń-Drozdowska & Majewska, 2016; WEF, 2017, 2-3).

In the group of higher-income economies two clusters of variables appeared. The first cluster contained five variables: GERD *pc*, GDP *pc*, EXPLSM, EXPMSM, and EXPHSM. The node between GDP *pc* and GERD *pc* is the central element of this cluster to which high-skill and technology-intensive manufactures first join. Next at longer distance to these three variables joins the node between EXPLSM and EXPMSM, but these variables are relative close together. This is probably due to the fact that in more developed economies the production structure has been reallocated faster and on a larger scale towards requiring higher skills of labor resources. The second cluster contained the unemployment rate and labor-intensive and resource-intensive

manufactures. Again, the results of cluster analysis coincide with the results of correlation analysis. Primary commodities, precious stones and non-monetary gold exports were the most distance from other examined variables.

4. Conclusion

The results of our research are consistent with the economic development theory. Because they indicate firstly that the nature of the relationship between the unemployment rate and innovation activity may affect both positive and negative changes in the technological sophistication of production structure, and thus exports. In line with expectations, the rise in the unemployment rate increases the shares of less technological-intensive and more labour-intensive manufactures, and decreases the shares of more technology-intensive products in the overall export structure.

Secondly, the two-way relationship between the increase in expenditure on R&D and the decline in the unemployment rate appears in our research. This means that a decrease in the unemployment rate may impact the growth of innovation activity, which in turn generates the further decline in the unemployment rate. However, it is more typical for higher-income countries, already possessing a sufficiently developed economic structure and a well-functioning labor market, what is also confirmed by the results of our research. In this context, it is worth recalling the words of Davenport and Kirby (2015, p. 60), which refer to today's mature economies: *Instead of seeing work as a zero-sum game with machines taking an ever greater share, we might see growing possibilities for employment. We could reframe the threat of automation as an opportunity for augmentation.*

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