

# SELECTION AND ASSORTMENT OF THE VARIABLES DESCRIBING THE RELATIONSHIP BETWEEN THE ECONOMY AND THE GENERAL GOVERNMENT SECTOR SIZE BY APPLICATION OF THE LEM2 ALGORITHM

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## Abstract

This paper reverses the relatively frequent examined interrelation that links an impact of the public sector (and within it the general government sector) on the economy of the analyzed countries. The article analyses whether the size of the general government sector is a function of the economy expressed through variables that were adopted for research. Realization of the research objective that was raised in this article focused on typing, grouping and selecting variables that describe respectively: the economy and the size of the sector. For identifying relationships between variables assigned to each group, the LEM2 algorithm was used. Rules that were generated by the application of this algorithm provided not only information about the relationships of individual variables, but also provided an indication of how frequently they occurred in relation to the examined pairs of variables describing the economy and the size of the general government sector. The subject of research was EU Member States (their economy and public finance systems) and the research period was set on the years 2000 to 2013 (inclusive). Among the economic variables and variables describing the size of the sector, there were included both standard variables used in the analyzes dedicated to macroeconomic issues as well as variables that the authors' team selected in order to test their applicability in describing the economy and the size of the general government sector. Such a composition of the variables is well-founded as, besides the main objective of this article (i.e. to establish a link between the economic situation and size of the general government sector) the additional effect of research, and that is the optimization of the selected variables that are used to explain the relationship of the economy and the size of the sector.

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## INTRODUCTION

The public sector (including the general government sector) and the economy are linked together naturally. The public finance system, which allows functioning of the general government sector, is formed by the economic processes and the structure of the sector co-creates the economic system of each country. At the same time the size of the general government sector also affects the economy. Both the size and structure of the sector constitutes a burden for the economic organism. There is therefore no doubt of the fact of mutual dependences of the economy and the general government sector. As the economy cannot function without the participation of the public sector, depending on the conceptual approach, to a lesser or greater extent engaged in the realization of activities related to allocation, redistribution and stabilization - as a source of financing of the general government sector it is the economy and the entities that it is formed from.

As the interrelation indicated above is intuitive, in as much the issue of its scale is controversial. The question is: to what extent the economy providing the funds to achieve public duties is charged by the costs of activities of the sector and to what extent indicated the charges translate into business results of the general government sector entities identified in the economy? The issue that links the functioning of the general government sector with the economy was recognized in science and it remains the object of researches that are being started and continued relatively often. The issue of the impact - generally speaking - the public sector on the economy, was undertaken in recent years inter alia by the following authors: Skica (2014); Di Liddo et al., (2013); Bergh and Henrekson (2011); as well as Josheski et al., (2011); Afonso and Furceri (2010); Alesina and Ardagna (2009) and Chobanov and Mladenova (2009). Whereas among the oldest scientific papers that are dedicated to the issues under analysis, the following authors have to be mentioned: Rubinson (1977); Cameron (1978); Peltzman (1980); as well as Katz et. al., (1983); Landau (1983); Saunders (1984); and Conte and Darrat (1988); Bairam (1988); and Barth and Bradley (1988). A feature that combines these studies, regardless of the span of time intervals of their publications, is bipolarity of distribution of the research hypotheses, which takes into account positive and negative impact of the size of the general

government sector on the economy. The positive impact on the economy was proven by inter alia: Heitger (2001); Torstensson (1994); as well as Easterly and Rebelo (1993), and Ram (1986). Whereas negative relationships between size of the sector and the economy were found by among others: Gwartney et al., (2002); Strauch and Hagen (2000); as well as Rodrik (2000); and Mueller (1997). This list shows a lack of consistency of the research results and thus a clear answer to the question of stimulating the economy or discouragement of an economy by the size of the general government sector. A partial attempt to answer this question can be found in the studies whose objective was set on development of methods for measuring the size of the general government sector as well as optimization of its size from the perspective of the national economy (compared inter alia by Di Matteo (2013); Magazzino and Forte (2010); Witte and Moesen (2010); Chobanov and Mladenova (2009); Gunalp and Dincer (2005), Pevcin (2004a). Nevertheless, those studies also present sometimes different results in the area of optimal sector's sizes for the economy, which do not provide a clear answer to the question about the optimal size.

The purpose of this article is to investigate if the structure and the size of the economy are the determinants of the size of the general government sector.

## LITERATURE REVIEW

Analysis of the research published up to now, which were dedicated to the relationships between the economy and the size of the public sector, shows some regularities. These findings are crucial for our further analysis. Epifani and Gancia (2009) defend the premise that trade openness can cause the increase of the size of government. This opinion fits in the results of previous analyzes, which were made by inter alia: Garen and Trask (2005); Islam (2004); Garrett (2001), as well as Alesina and Wacziarg (1998) (who examined the relationship between the size of the country(state) and the size of the public sector) and Rodrik (1998) (analysis of the interrelation between the open economies and the measuring of government and sector). At the same time Alesina and Wacziarg (1998) stated that the government size is smaller in bigger economies. In the context of analyses dedicated to trade openness and its relation with government size, there are also the options of Quinn (1997), according to

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which higher levels of capital mobility are associated with higher levels of government spending.

Another concept that explains growth in government size from the economic side is the theory given by Baumol (1967) bearing its name from the name of its author - Baumol's cost disease. In accordance to the content of this concept this 'illness' has symptoms in constant increase of relative prices of government - provided goods and services, which ultimately increases the relative size of government in the economy. The reasons of this situation are limited possibilities for technological progress, as a consequence of the orientation of the activity of public sector resources for labor in the process of delivery of goods and the provision of public services. In the private sector these changes occur much faster and more smoothly. As a result, the public sector in comparison with the private sector has a lower productivity and higher operating costs, measured as a relationship of expenditures to GDP that express the government size. Baumol's position was verified through study in the literature by, among others Berry and Lowery (1984) and Ferris and West (1996).

According to the point of view of Niskanen (1971), the causative agent of growth in government size is the continuing impact of bureaucrats on self - expansion and thus, enlarging the scale of its impact. This model in its assumptions is consistent with the Leviathan model, because it is based on the assertion that government size is larger than the citizens would expect, i.e. the beneficiaries of its activities. Moreover - referring to this concept, Brennan and Buchanan (1980) state that the decentralization of public authority and public finances leads to reduction in government size. One has to however remember that the financial decentralization refers mainly to activities in the area of spending, and that means that independency in making expenditure decisions does not necessarily translate into the reduction in government size, measured by share of government spending in GDP.

Boix (2001), explains that the size of government that is defined by current receipts of the general government is being shaped by three groups of variables: 1) the economy (includes the set of variables that measure the effects of economic modernization on the size of government); 2) trade; 3) political institutions. According to the collected results, the process of economic modernization (development), leads to a larger public sector.

Pevcin (2004b), who focuses inclusively on budgetary

government (i.e. by measuring the size of government size with a certain government spending ratio), proved that economic factors (the ones from the economy) are way more important in explaining changes of the government size that is measured by consumer spending, whereas political (social ones) and cultural factors play a bigger role in explaining changes in the size of the government that is measured by the transfer spending.

Grammy (2007) in contrast to Pevcin (2004b) in the analysis of economic, social, political, demographic and cultural factors that have influence on differences in the size of government in a cross-section of particular countries, embraced in his analysis not only budgetary government (expressed usually with some government spending ratio), but also non-budgetary government (measured with the index of the extent of regulation in the economy). According to the results of analysis, the economic factors play a greater role in explaining the variation in the size of government consumption and in the size of the non-budgetary government, whereas the political, social and cultural factors are more important in explaining the variation in the size of transfers.

Anwar (2005) focuses on the impact of changes in the supply of primary factors such as capital and labor on the size of government (measured by the ratio of the public and the final good produced). According to the research assumptions, the increase of supply on capital decrease the size of government when the final good is equally (or more) capital intensive as compared to the public good. On the other hand, the increase of supply of labor force (resource of labor factor) can increase the government size only when external economies enjoyed by the final good producers are sufficiently small. Otherwise, impact on the size of government can be equal to zero or negative. In the presented considerations, there is one more thread, namely the relationship between the size of the country and the size of government. This article proved that the increase in the size of the country leads to a decrease in the size of government as long as the specialization-based external economies are present.

Holley and Borcharding (1997) and Persson and Tabellini (1999) are of the opinion that the size of government is determined by the level of economic development of the country (the more developed the country the greater the government size). This position also corresponds with Wagner's law according to which government spending grows with economic development

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of the country. The concept of Wagner was verified by, among others, Gemmell (1993); Henrekson (1993); and Oxley (1994); Chletsos and Kollias (1997); Thornton (1999); and Islam (2001); Chang (2002); and Iyare and Lorde (2004); and the results obtained by them alternately confirmed the concept of Wagner or negated it. Returning to the position of Holsley and Borchherding (1997) the size of the population (number of inhabitants of a country), has a positive effect on the demand for public services and consequently on government spending (i.e., the measure of both the government and the general government sector). McNutt (1996) referring to the presented view suggests that the government should spend more in societies with relatively unequal income distribution. Thus, the author indicates another economic factor that shapes the size of the government.

The presented views correspond with two opinions in the area of research approaches on the size of government. The first of them is based on aggregated demand. Demand factors of the size of government growth were mentioned in the papers of, among others, Peacock and Wiseman (1961); Berry and Lowery (1987); and Payne (1991); Rowley and Tollison (1994); Alesina and Perrotti (1995); Kraan (1996); and Kau and Rubin (2002). A common feature of the studies listed above is to explain the increase in government size with the implications of socio-economic development, the consequence of which is the allocation of public resources leading to: replacement of the market mechanisms of funds allocation by the budget, the gradual strengthening of the ideologies that promote the growth of the public sector, thereby increasing society's expectations towards liquidation through the budget problems resulting from social issues. As a result of growing expectations of the budget, which are related to its stabilizing role in the economy, the sector's size is increasing.

Alternative to the demand approach to explain the reasons of government's size increase is the approach based on aggregated supply. This opinion is found both in earlier scientific works of Baumol (1967); Downs (1967); and Niskanen (1971); Tullcok (1980); Buchanan (1980); as well as in more recent papers of authors such as Mueller, (2003). The statement that links the opinions of the presented authors is the conclusion according to which the primary objective of government is to provide public goods and services (shaping of their supply). The increase of the supply size is however not always caused by a real

increase in demand for public goods and services in the economy. In other words, the level of supply is often a consequence of the shape of its size in the previous years. As a result, the expansions of the size of government are more often observed than the reduction that is the consequence of the reduction in the supply's size. When we add to this effectiveness of public sector entities which is lower than in the private sector, we can observe increase in the size of the supply - that is accompanied by the increase of associated costs of providing public goods and services, which is featured by participation of government spending in GDP, i.e. increase in the size of government.

Analysis of the literature revealed a wide diversity of research approaches concerning the relationship between the economy and the size of the general government sector, diversification of measures applied to express the sector's size and at the same time proven discrepancies in the results of ongoing research. Demonstrated facts are the proof that the research on a topical relationship was not clearly resolved, so it remains constantly current. Among a number of questions which are the result of the conducted literature review, and additionally of a diversified research approach, the selection of variables explaining an identified relationship (on both the economy side and the side of the size of the general government sector) should be also mentioned. This article is an attempt to link and resolve both of these issues. Firstly, in analyzes concerning the relationship of the economy and the size of the general government, the LEM2 algorithm has not been used so far. Thus, the added value of this article is an application of a research approach that was different from the ones that were previously used. Secondly, the method of construction of a selection of variables that were used to describe both the economy and the size of the sector, combines the classical approach to such analyzes and the variables adopted by the authors in order to verify their usability in analyzing the interrelation under examination. The selection of variables that was designed this way is, besides the main objective of this article (which is identification of the relationship between the economy and the size of the general government sector) the additional results of scientific research in the form of an optimization of the catalogue of the variables that are being analyzed to explain the relationship of the economy and the size of the sector.

## STRUCTURE AND SCOPE OF VARIABLES APPLIED TO DESCRIBE THE ECONOMY AND GENERAL GOVERNMENT SECTOR SIZE

The first stage of the research was to determine the object (subject) of analyzes i.e. countries whose economies and systems of public finance will serve to verify the research objective. The research sample that was selected was a number of EU Member States and the research period was set on the years 2000 to 2013 (inclusive). From the adopted period of time, the authors eliminated the year 2001, due to the very large amount

of missing statistical data required for the description of the economies of the EU members and the general government sector. Thus in the research process, the authors conducted the analysis of 27 EU Member States in the period of 13 years of their performance.

The second stage of the research was focused on typing and selecting variables, which were used to describe economies and the size of the general government sector of countries that were selected for this research. Referring to the research objective, in order to describe the economy, the authors selected 18 variables (see: Table 1) and in order to present size of the general government sector 15 variables (see: Table 2).

**Table 1: The catalogue of variables describing economies of EU Member States that were adopted in research**

No	Name	Unit
1	External balance of goods and services	Million Euro
2	Gross Domestic Product in current prices	GDP per inhabitant
3	Production in industry – dynamic	Percentage change compared to same period in previous year
4	Balance of the current account	Million Euro
5	Potential output of total economy	Million Euro
6	Harmonized Indices of Consumer Prices (HICPs)	Annual average rate of change
7	Inward FDI flows	Million USD
8	FDI (Foreign direct investment)	Million USD
9	Real effective exchange rate	Index 1999 = 100
10	Human Development Index – HDI	Value from 0 to 1
11	Outward FDI flows	Million USD
12	Growth rates of GDP	Percentage change
13	Gross capital formation	% GDP
14	Gross Domestic Product in current prices (per inhabitant) – dynamic	Percentage change
15	Activity rate	In %
16	Retail sales – dynamic	Index of turnover – Total 2010 = 100
17	Potential output of total economy - dynamic	Annual average rate of growth – percentage
18	Unemployment rate	In %

Source: Own work

**Table 2: Catalogue of variables describing size of general government sector that were adopted in research**

No	Name	Unit
1	General government gross capital formation	% GDP
2	Government consolidated gross debt	% GDP
3	Public sector employment	Number of people
4	Total general government expenditure (Per inhabitant)	Euro per inhabitant
5	Total general government revenue (Per inhabitant)	Euro per inhabitant
6	Net lending/ borrowing	Million Euro
7	Total general government expenditure	% GDP
8	Central government deficit	% GDP
9	General government sector output	% GDP
10	Gross value added (or General government total value-added)	Basic (current) prices
11	The ratio of total taxes to GDP	% GDP
12	Final consumption expenditure	% GDP
13	General government deficit	% GDP
14	Total general government revenue	% GDP
15	General government gross fixed capital formation	% GDP

*Source: Own work*

The variables included in Table 1 and in Table 2 were selected based on the criterion of continuity of data at a time, and their availability for the countries that were examined. The result is an array of statistical data, which has three dimensions covering 27 countries, 13 years, 18 and 15 variables referring successively to economy and the size of the general government sector.

Due to the fact that the purpose of this article is identification of existence (in the general sense) of the relationship between the economy of the examined countries and the size of the general government sector, in this study collected data describing on an individual basis the particular states was aggregated. Due to this fact, for the purpose of research, the authors created a set of statistics describing in time (years 2000-2013) and in space (i.e. in relation to the 27 EU countries), the economy and the size of the general government sector, of the entire sample test, in place of data describing every single EU member state separately. This aggregation does not however mean that information about individual countries have been omitted, and thus eliminated. Each row in the input table for the purposes of the algorithm LEM2 is the information about the economic situation of the country. The statistical data that was collected by using the above criterion were found to be incomplete, and in addition it contained minor errors and anomalies. Considering the above, the first step was to execute initial

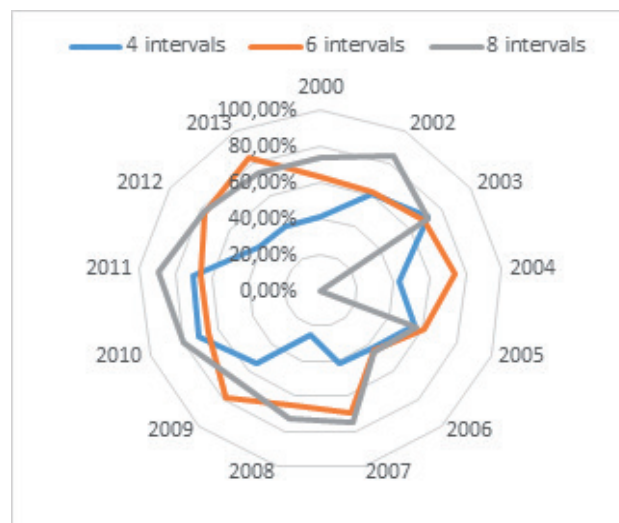
data processing and data purging in order to prepare them to carry out computational actions. Then, due to the mentioned incompleteness of data in the whole examined time series, the analyzes included only these variables, in relation to which the deficiencies of data was lower than 1/3 of all the values. At the same time, in order to complement missing values for the different variables, the authors used generalized additive models with special emphasis on the method of K - nearest neighbors.

The gathered output statistics data (both economic data as well as data describing the size of the general government sector), were continuous. Therefore, to ensure consistency, and with the unification of the variables' values, the authors conducted the discretization. It included exchange of continuous values by the discrete values (hence the name of this process - discretization), which corresponds to a certain interval of continuous value of the original attribute (variable). As a result of discretization, the obtained ranges of values become ordered. Thus, in place of the continuous attribute (i.e. each economic variable and each variable describing the size of the sector) the authors obtained an ordered attribute (variable) with finite number of values. The discretization process was conducted using the method based on the division of each variable, so that each of the sets of economic variables and variables describing the size of the general government sector contained

exactly the same fixed number of intervals. In the next step, each variable was matched with new discrete values. Due to the conducted discretization, new discrete values ensured even distribution. The study highlights the three compartments discretization: 1) discretization of four-intervals; 2) discretization of six-interval; 3) discretization of eight-intervals, and the research that lead to identification of the best classifier was conducted

in parallel on each of these groups. For this purpose, each of the three sets of data was subjected to classification. Classification was conducted in the system RSES (Szczuka, Mikolajczyk & Baza, 2005), using the method of cross validation. Accuracy error of a classification of each from the three discretization methods for selected attribute of general government gross capital formation is shown in Figure 1.

**Figure 1: Error of classification accuracy obtained for various discretization intervals for an attribute general government gross capital formation**



Source: Own elaboration

In the result of the conducted research activities, the best outcomes of the classification were obtained in the group of data with discretization of four-intervals. Due to this fact, in the next part of the analysis, the authors analyzed the model that was built based on the rules that were generated based on this data (i.e. data that is based on discretization of four-intervals).

## RESEARCH METHODOLOGY

Literature review analysis proved the number of both methods and algorithms that are aimed at the statistical data analysis. Conducted literature studies have however shown that so far in the analysis of the relationship between the economy and the size of the general government sector, there was no application of approach based on rule-based algorithms. Representation of knowledge in the form of the rules is regarded by many authors as more readable to humans than other representations: Michalski (1997) and Quinlan (1993). The various authors

are also stressing its modularity and usability to analysis of single rules by an expert. Decision-making rules are used in many successful applications of machine learning and knowledge discovery, by Fayyad, Piatetsky-Shapiro and Smyth (1996); Slowinski, Stefanowski and Sowiński (2002). Representation of data in the form of rules can be sourced from an expert in a particular field of application or extracted from experimental data tables (see: Fritz, Armor & Suraj, 2004). In the present case the primary knowledge is stored in the form of so-called decision-making systems in the sense expressed by Pawlak (see: Pawlak, 1982).

Rows in the decision-making tables represent the countries under examination, which are called objects. The columns represent sets of features (attributes) of these objects. The set of attributes is composed of two separable parts: a set of so-called conditional attributes that describe the analyzed objects and a set of so-called decision-making attributes. In our study, the set of attributes corresponds to the data describing an economy (see: Table 1), while a set of decision-making attributes in

a single set corresponds in every decision-making system to another variable describing the general government sector (see: Table 2).

Formally a decision system is a set in the form of  $S = (U, A \cup \{d\})$ , where  $A \cap \{d\} = \emptyset$ . Set  $\{d\}$  is a set of distinguished attribute called a decision. The elements

of  $A$  are called conditional attributes (or conditions, in short). Let  $S = (U, A')$  be a decision system, where  $A' = A \cup \{d\}$  and let  $V'$  be the domain of  $A'$ . Pairs  $(a, v)$ , where  $a \in A', v \in V'$  are called descriptors over  $A'$  and  $V'$  (or over  $S$ , in short). Instead of  $(a, v)$  we write also  $a=v$  or  $a_v$ . The example of a decision system is presented in Figure 2.

Figure 2: Decision system that consists of sample data for the variable central government deficit

27/17	Unemployment rate	External balance of goods and services	FDI (Foreign direct investment)	Gross capital formation	Human Development Index – HDI	Harmonised Indices of Consumer Prices (HICPs)	Inward FDI flows	Outward FDI flows	Gross Domestic Product in current prices (per inhabitant) – dynamic	Gross Domestic Product in current prices	Production in industry – dynamic	Real effective exchange rate	Balance of the current account	Potential output of total economy	Activity rate
0:01	1	1	1	3	3	4	1	1	1	3	3	1	4	3	1
0:02	2	1	1	2	4	4	2	2	1	2	2	1	3	4	1
0:03	4	1	1	1	1	3	1	1	3	1	2	1	3	2	1
0:04	1	1	1	1	2	4	1	1	1	2	2	1	4	2	1
0:05	2	1	1	4	2	4	1	1	2	1	2	1	3	3	1
0:06	1	2	1	2	4	4	1	1	1	3	2	1	4	1	1
0:07	3	1	1	4	2	4	1	1	3	1	4	1	3	1	1
0:08	2	2	1	2	3	4	1	1	2	2	3	1	3	2	1
0:09	2	1	4	1	3	4	1	4	1	2	2	1	4	1	3
0:10	2	1	1	2	3	4	4	1	1	2	2	1	1	3	4
0:11	3	1	1	3	2	4	1	1	3	1	3	1	4	2	1
0:12	1	1	1	4	1	3	1	1	2	1	4	1	3	2	1
0:13	1	2	1	3	4	4	1	1	3	3	4	1	3	2	1
0:14	2	1	1	2	3	4	1	1	1	2	2	1	3	1	3
0:15	3	1	1	3	1	3	1	1	4	1	1	2	3	2	1
0:16	4	1	1	1	1	4	1	1	4	1	1	1	3	2	1
0:17	1	4	1	2	4	4	1	1	2	4	2	1	4	3	1
0:18	2	1	1	3	1	4	1	1	3	1	2	1	3	2	1
0:19	1	2	2	2	4	4	2	2	2	3	2	1	3	4	1
0:20	4	1	1	3	2	4	1	1	4	1	2	1	3	4	2
0:21	1	1	1	4	2	4	1	1	1	1	3	1	4	2	1
0:22	2	1	1	1	1	1	1	1	4	1	2	4	3	2	2
0:23	4	1	1	3	2	3	1	1	3	1	3	1	3	4	1
0:23	2	1	1	4	3	3	1	1	1	1	3	2	3	2	1
0:25	3	1	1	3	3	4	1	1	2	2	2	1	4	4	2
0:26	1	2	1	1	4	4	1	1	2	3	2	2	3	3	1
0:27	1	1	4	1	4	4	3	4	3	3	2	2	4	1	3

Source: Own elaboration

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From the decision-making system, the rules called decision-making rules are generated. These rules represent the relationship between the values of conditional attributes and values of decision-making attributes. The advantage of rule-based representation is the ease of translating them into the natural language. There are many algorithms of generating decision-making rules, but because of the use of algorithms to their further analysis and the relatively small sets of generated rules, the LEM2 algorithm was selected, which was also proposed by Grzymała-Busse (1992). This algorithm is used in the construction of learning models, in the form of a set of rules generated from data tables, and its implementation in an RSES system provides a simple record of generated rules, and their further analysis at the same time. In this study the rules were generated using automatic settings. All of the rules that were generated in the set have a general form:

$$(a_{i1} = v_{i1}) \& (a_{i2} = v_{i2}) \& \dots \& (a_{ir} = v_{ir}) = (d_k = v_k),$$

where:  $a_{ij} \in A_i$ ,  $v_{ij} \in V_{aij}$ , for  $j = 1, \dots, r$  and  $d_k \in D$ ,  $v_k \in V_{dk}$ ,

The sets of rules that were generated in the RSES system were the subject of further analysis. As part of these analyzes, the authors generated two major lists that show relationship of the attributes that characterize the economy with the individual variables describing the size of the general government sector in the period 2000-2013. A precise analysis of the generated rules is described in the next section.

## RESEARCH RESULTS

The study of the research works published up to now, which were dedicated to the relationships between the economy and the size of the public sector, shows a number of facts. The first one is far less frequency of attempts that are dedicated to review of the analyzed issue under the assumption of defining indicators describing the economy as a whole, and not just by its individual components. The second regularity deals with the fact that the great majority of researches consider the interrelation between the economy expressed by indicators selected with the idea of presenting its specific area. Thirdly and finally, the individual variables presenting the economy are juxtaposed the most often to the size of government (i.e. the central government). The authors in their works use the same narrower spectrum of research - putting

on the side of 'explaining variable' only one component of the general government sector which is government authority, and leaving aside the analysis of the remaining components of the sector, i.e. state government (among EU countries this component of the general government sector concerns only Belgium, Germany, Spain, Austria and Switzerland), and / or local government and social security funds.

Literature review revealed a classical orientation in research devoted to public sector entities and their relations with an economy. The authors of this article present a completely different point of view on how to analyze the relationship between the economy and the size of the general government sector. Accordingly, this article creates a new approach for studying these topics. Realization of research works that involved identification of the relationship between the economy and the size of the general government sector started from the determination of an answer to the question about the number of rules indicating relationship between the economy and the size of the general government sector (separately for each year under examination). The investigated relationship was identified by using all variables of a sector and all variables describing the economy. According to the results of research findings, the number of rules proving the relationship between the economy and the size of the general government sector fluctuated in the range from 124 rules (in 2009) to 179 rules (in 2007). In the scale of the whole analyzed period, the number of rules closed on the number of 1 990.

The research proved that the variable on the economy's side, which in the entire period under examination with the exception of the first and the last year (i.e. the year 2000 and 2013), was characterized by the greatest frequency of occurrences in the rules indicating the relationship of the economy and the size of the sector, was a variable called external balance of goods and services (in million euro). Thus, this economic variable to the largest extent indicated a relationship that was identified in the study. The presence of this indicator in the rules for the different years, which was referenced to the total number of rules, which in a given year proved the relationship between economic variables and the variables describing the size of the general government sector in the entire examined period, ranged from 77% in 2002 (120 occurrences in 156 rules, for this whole year), up to 98% rule in 2007 (176 occurrences in 179 rules, for

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this whole year). In contrast, the variable that in 2000 and 2013 was characterized by the highest frequency of occurrences in the rules was the one called FDI - foreign direct investment (in million USD). In the first of the mentioned years, the variable occurred in 87% of the rules, and in the last year it reached a level of 92% occurrences in the rules explaining the relationship between the economy and the size of the general government sector.

The reversal of analyzed interrelation i.e. identification of the variables on the side of the economy, which in a cross section of a single year were characterized by the lowest percentage of occurrences in the total number of rules that in a given year described the relationship between the economy and the size of the general government sector, determined that in the whole analyzed period there was not a single variable that in all years had continuously the lowest frequency of occurrences in the rules. Nevertheless, it was possible to select such a variable, which in the years 2000-2013 (inclusive), had decidedly the lowest number of occurrences in the rules describing the examined relationship with the highest frequency. According to the findings of the research the lowest frequency of occurrences in the rules describing the relationship between the economy and the size of the general government sector concerned a variable called the Human Development Index - HDI (value from 0 to 1) that was ranged from 3% in 2002 to 6% in 2007. This variable in the year 2002 occurred only in 4 out of 156 rules indicating the relationship of the economy and the size of the sector, and in the year 2007 (the best for this variable), it was noted in only 10 out of the 179 rules identified for the entire year 2007.

In the next stage of the research, the authors made the attempt to determine which variables describing the economy and which variables presenting the size of the general government sector was found in the interrelation, and also how the sum of their occurrences in the rules describing the relationship of the economy to the size of the sector in the years 2000-2013 (inclusive) was presented. In accordance with its contents, the statistics of occurrences of the attributes determining size of the general government sector in the rules describing the relationship of the economy and the size of the sector, was pointed out by two variables. The first sector-determining variable, which occurred the most frequently in the rules describing the relationship between the economy and the size of the general government sector was the variable

called gross value added (the general government total value-added) (basic (current) prices), whereas the second variable was the one named general government gross capital formation (% GDP).

In turn, the variable called public sector employment (number of people) was found to be the one among the sector-determining variables in the rules describing the relationship of the economy and the size of the general government sector in the entire period 2000-2013 that presented the rarest occurrences. In the case of 17 out of 18 variables that illustrate the size of the general government sector, the smallest number of occurrences in the rules describing the relationship of the economy and the size of the sector precisely concerned this variable. In the other separate case, a variable named total general government revenue (euro per inhabitant) presenting the size of the general government sector occurred in the smallest number of rules with the economic variable called potential output of the total economy (in million euro).

Thus, the difference in the frequency of occurrences between a sector-determining variable that was found the most and the least frequently in the rules describing the relationship of the economy and the size of the general government sector, was established on the level of 149. The variable called gross value added (the general government total value-added) basic (current) prices) occurred in 152 of the rules with the economic variable called external balance of goods and services (million euro). As a result, this sector-determining variable was the most commonly occurring that was identified in the rules describing the relationship of the economy and the size of the general government sector. On the other hand, the variable called total general government revenue (euro per inhabitant) occurred in just 3 rules with the economic variable called potential output of the total economy (million euro). This means that it was the sector-determining variable that occurred in the decidedly smallest number of rules describing the relationship of the economy and the size of the general government sector.

According to the research assumption that was adopted in the article, the authors showed the number of years in the examined period from 2000 to 2013 (inclusive), in which they identified the relationship between a single variable describing the economy and a single variable presenting the size of the general government sector. The authors took here the assumption that the proportion of

the number of occurrences of a given economy-describing attribute to the number of rules that describe the size of the general government sector in a given year was higher than 50%. The variables describing the economy that showed the strongest relationship with the variables describing the size of the general government sector, were the ratios called: the external balance of goods and services (million euro), as well as FDI - foreign direct investment (million USD) and gross domestic product in current prices per inhabitant (GDP per inhabitant). All the presented economic variables during the period of 13 years (i.e. the entire analyzed period), were associated with a variable presenting the size of the general government sector. Another economic variable in terms of stability of the relationship was the parameter called unemployment rate (in %). It remained in the relationship with variables presenting the size of the general government sector in 12 out of 13 years of the analyzed period. Finally, the third economic variable, in terms of the sustainability of the relationship between the economy and the size of the general government sector, was the parameter called real effective exchange rate (Index 1999 = 100). This attribute had a relationship with the sector's size in 10 out of the 13 analyzed years.

Using the applied criterion of 50% as the threshold for acceptability of variables for further study, it was possible to identify the broadest relationships between variables belonging to the economy and variables illustrating the size of the sector. According to the research findings, the broadest scale of relationships between variables describing the economy and variables presenting the size of the general government sector, was found in the case of the following attributes: 1) unemployment rate (in %); 2) the external balance of goods and services (million euro); 3) FDI - foreign direct investment (million USD); 4) harmonized indices of consumer prices (HICPs) (annual average rate of change); 5) inward FDI flows (million USD); 6) the gross domestic product in current prices per inhabitant (GDP per inhabitant); 7) real effective exchange rate (index 1999 = 100); 8) potential output of the total economy (dynamic annual average rate of growth - percentage). These economic variables occurred in the rules with 15 (so all) variables describing the size of the general government sector. Another group of economic variables, which was characterized by a very large scale of relationships with the sector-determining variables, was composed by following attributes of FDI flows (million USD), as well as the balance of the current account

(million euro) and gross capital formation (% GDP). The first from these variables remained with no relationship with the ratio called public sector employment (number of people), which means that it was linked with 14 out of 15 of sector-determining variables. The remaining two variables presented the relationship with 13 variables describing the size of the general government sector. The attribute that is called balance of the current account (million euro), did not occur in the rules with variables: general government gross capital formation (% GDP) and public sector employment (number of people). Whereas the attribute called gross capital formation (% GDP), besides the fact of not occurring in the rules with variable public sector employment (number of people), stayed neutral also in relation to the variable called total general government revenue (euro per inhabitant).

#### **FINAL CLASSIFICATION OF THE VARIABLES DESCRIBING RELATIONSHIP BETWEEN THE ECONOMY AND THE GENERAL GOVERNMENT SECTOR SIZE**

The conducted analyzes provided for the development of four rankings that evaluate complementary aspects of the relationship under examination, which links economy and size of the general government sector. The separate rankings were aimed to build a classification showing the position of each economic parameter, which were evaluated using the criteria adopted for the construction of the ranking. Then, based on the classification of economic variables within each individual ranking, the authors determined the average ranking position for each economic variable and then ordered them by the criterion of the average ranking position. In the process of ranking development, the authors took the assumption in accordance to which the higher the rank of an economic variable the better it serves to explain the relation occurring between the economy and the size of the general government sector.

The first ranking referred to the maximum number of occurrences of the given attribute (on the side of the economy) in the rules describing size of the general government sector in the individual analyzed years. According to the ranking, the first three variables, i.e. the attributes describing the economy that occurred most frequently in the rules explaining the relationship of the economy and the size of the sector were: external balance

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of goods and services (in million euro), as well as FDI - foreign direct investment (in million USD) and the ratio called unemployment rate (in %).

The second ranking was based on the criterion of the number of relationships that were identified in relation to a single variable describing the economy with a single variable describing the size of the general government sector considering individual analyzed years. The greatest number of relationships with particular variables presenting the size of the sector, was found in the case of following economic variables: external balance of goods and services (in million euro) - 176 occurrences, harmonized indices of consumer prices (HICPs) (annual average rate of change) - 145 occurrences, as well as the real effective exchange rate (index 1999 = 100) - 144 occurrences.

The third ranking allowed us to answer the question as to which variables describing the economy and which variables describing sizes of the general government sector presented the largest frequency of relationships (in the examined period) which was measured with an application of number of years, where the authors identified links between the examined variables. Results of the research proved that the economic variable called external balance of goods and services (in million euro) was found in relationship with 11 variables of the sector: (i.e. 1) central government deficit (% GDP); 2) general government deficit (% GDP); 3) government consolidated gross debt (% GDP); 4) final consumption expenditure (% GDP); 5) general government gross capital formation (% GDP); 6) general government gross fixed capital formation (% GDP); 7) gross value added (general government total value-added) (basic (current) prices); 8) general government sector output (% GDP); 9) total general government expenditure (% GDP); 10) total general government revenue (% GDP); 11) net lending/ borrowing (million euro). This relationship remained untouched in the whole analyzed period (i.e. in the years 2000-2013 inclusive).

The last, fourth ranking was prepared on the basis of the criterion of the number of occurrences of the variable describing the economy in rules describing the relationship of the size of the general government sector. The ranking was developed on the assumption that the ratio of the number of occurrences of a given attribute (presenting the economy) to the number of rules that describe the size of the general government sector was higher than 50% in

a given year. According to the established criterion, there was even 8 economic variables that showed a relationship with all 15 variables describing the size of the general government sector. Among these variables, there were the following economic attributes: 1) unemployment rate (in %); 2) external balance of goods and services (in million euro); 3) FDI - foreign direct investment (in million USD); 4) harmonized indices of consumer prices (HICPs) (annual average rate of change); 5) inward FDI flows (in million USD); 6) gross domestic product in current prices per inhabitant (GDP per inhabitant); 7) real effective exchange rate (index 1999 = 100); 8) potential output of the total economy (dynamic annual average rate of growth - percentage).

The presented individual rankings that relate to the classification of economic attributes were used to develop a collective ranking of variables describing the economy (see: Table 3). This ranking was constructed to determine the suitability of particular economic variables in explaining dependency on the line: the economy - the size of the general government sector. This ranking is built on the basis of information about the average ranking position for each variable describing the economy, which was determined based on the positions from all four rankings. In this way, the attributes defining the economy were ordered according to the criterion of the average ranking position occupied by a particular variable. For a classification prepared in such a way, the authors took the assumption according to which the higher the rank of the variable describing the economy, the better it qualifies to explain the relationship between the economy and the size of the general government sector.

According to this ranking, the first position was taken by the variable called external balance of goods and services (in million euro). On the second position, there was a parameter called FDI - foreign direct investment (in million USD). Due to this fact, both presented economic variables were classified to explain the relations on the line: economy – size of the general government sector to the decidedly largest extent. On the third place there were in parallel four economic variables, i.e. unemployment rate (in %), gross domestic product in current prices per inhabitant (GDP per inhabitant), as well as real effective exchange rate (index 1999 = 100) and harmonized indices of consumer prices (HICPs) (annual average rate of change). Fourth place was taken ex aequo by the variable called: outward FDI flows in (million USD) and inward FDI

flows (in million USD). In turn, the fifth place was taken by the variable called balance of the current account (in million euro). Sixth place (similarly to the fourth position), was taken by two economic variables in parallel: potential output of the total economy (dynamic annual average rate of growth - percentage) and gross capital formation (% GDP), and seventh place was taken by the variable called gross domestic product in current prices per inhabitant - dynamic (percentage change). Eighth standing was taken by three economic variables, namely: activity rate (in %), then production in industry – dynamic (percentage change compared to same period in previous year ) and Human Development Index – HDI (value from 0 to 1). Second last (the ninth) position was taken by the variable called potential output of total economy (in million euro). Finally the last 10th place was again taken ex aequo by two economic variables and these were: growth rates of GDP (percentage change) and retail sales - dynamic index of turnover (total 2010 = 100). These variables proved their smallest usefulness in explaining

the relationship between an economy and the size of the general government sector.

The completed research on the relationship between an economy and the size of the general government sector showed a new path in the analysis devoted to the public sector. The authors proved that it is possible to describe this relationship by application of the LEM2 algorithm. Moreover, besides the new method of analysis, the authors applied in their research new variables describing the size of the general government sector. Finally, the article changed the typical direction of analysis present in the research works, from public sector impact on the economy to the relationship between the economy and the size of the general government sector. All of these elements create a new value added in the knowledge on how the public sector should be analyzed and how we should link together the economy and general government sector.

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**Table 3: Classification of variables describing economy that indicated „the strongest” relationship with the variables describing size of the general government sector by the criteria of average ranking position of the given variable in the particular rankings**

Name of variable describing economy	Ranking 1	Ranking 2	Ranking 3	Ranking 4	Average ranking position of variable	Variable describing economy that indicated the most frequent relationship with the size of general government sector *
External balance of goods and services (Million Euro)	1	1	1	1	1	1
FDI - Foreign direct investment (Million USD)	2	5	1	1	2	2
Unemployment rate (In %)	3	4	2	1	3	3
Gross Domestic Product in current prices per inhabitant (GDP per inhabitant)	4	6	1	1	3	3
Real effective exchange rate (Index 1999 = 100)	5	3	3	1	3	3
Harmonized Indices of Consumer Prices (HICPs) (Annual average rate of change)	6	2	4	1	3	3
Outward FDI flows (Million USD)	9	7	4	2	6	4
Inward FDI flows (Million USD)	8	10	4	1	6	4
Balance of the current account (Million Euro)	10	9	7	3	7	5
Potential output of total economy (Dynamic Annual average rate of growth - percentage)	7	18	4	1	8	6
Gross capital formation (% GDP)	11	12	7	3	8	6
Gross Domestic Product in current prices per inhabitant - dynamic (Percentage change)	13	11	7	4	9	7
Activity rate (In %)	12	13	8	6	10	8
Production in industry – dynamic (% change compared to same period in previous year)	14	15	6	6	10	8
Human Development Index – HDI (Value from 0 to 1)	17	14	5	5	10	8
Potential output of total economy (Million Euro)	18	8	9	9	11	9
Growth rates of GDP (Percentage change)	15	16	8	8	12	10
Retail sales - dynamic Index of turnover (Total 2010 = 100)	16	17	9	7	12	10

\*The ranking was elaborated with the assumption that the proportion of number of the occurrences of the attribute presenting economy to the number of rules describing size of the general government sector was greater than 50% in a given year.

Ranking 1. Ranking by maximum number of occurrences of a variable describing economy in the rules describing the sizes of general government sector in the period of 2000-2013 (inclusive)

Ranking 2. Ranking by the number of relationships that were identified with respect to single variable describing economy with the variable describing size of the general government sector in the period of 2000-2013 (inclusive)

Ranking 3. Ranking by the maximum number of years when the relationship between the variable describing economy and the variable describing the size of general government sector was identified in the period of 2000-2013 (inclusive)

Ranking 4. Ranking by the number of occurrences of variable describing economy in the rules describing the relationship with the size of general government sector in the period of 2000-2013 (inclusive)

*Source: Own work*

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