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DATA MINING APPROACH IN DETERMINING THE RELATIONSHIPS BETWEEN THE ECONOMY AND THE GENERAL GOVERNMENT SECTOR SIZE

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Abstract

This article is dedicated to a study of the relations between the economy and the size of the general government sector. The main aim of the article is an identification of the most important variables that are used to determine relations between the economy and size of the sector, as well as to identify frequency of their occurrences in relations to pairs of variables which describe an economy and the size of the sector. In order to explore these relations, the authors used Bayes networks. The economies of EU member states and their public finance systems were the object of analyses in this article. The period that was selected for the research covered the years 2000-2013 (inclusive). In order to describe economies, the authors selected 18 variables, whereas to describe the general government sector - 15 variables. These variables were sourced from databases of Eurostat, OECD and the World Bank. Among an economy's measures and general government sector measures, there were also some benchmarks found (standard and classic) as well as measures proposed by the authors, which had not been used in the scientific descriptions that were dedicated to research on size of the general government sector. Ipso facto, this article fits in the discussion on not only the size of the general government sector, but also attempts to answer the question of whether the economy determines the size of the sector. To date, the research questions on the impact of the size of the general government sector on the economy of a particular country have been common. This article inverts the investigated dependence and its content concentrates on the attempt to determine if the size of the sector in a particular country is a function of its economy expressed by ratios adopted in conducted the research.

JEL classification: E62, H11, H20, H50, H60
Keywords: economy, central government, general government sector, economy, public finance, relationship between economy and general government sector size

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Introduction

The authors identified plenteous literature on the topic on relations of the general government sector with the economy. In just recent years research on this topic has been conducted by inter alia Skica, 2014 and 2011; Di Liddo et al., 2013; Ruta et al., 2012; Josheski et. al., 2011; as well as De Witte and Moesen, 2010; Bergh and Henrekson, 2011; Afonso and Jalles, 2011; Bergh and Karlsson, 2010; Afonso & Furceri, 2010; Alesina and Ardagna, 2009; Colombier, 2009; Chobanov and Mladenova, 2009. This enumeration is not exhaustive and the number of attempts and approaches to explain the issue goes far beyond the given examples. Keeping in mind the above assumption, the authors can argue that the question of the optimum size of the general government sector, its impact on economic performance and the economic position of the state in comparison to countries of reference, are the subject of continuing studies.

The problem of relation of the general government sector's size and the economy is considered from both its positive impact on the economy (see, among others, Heitger, 2001; Torstensson, 1994; Easterly & Rebelo, 1993; as well as Conte & Darrat, 1998 and Ram, 1986) and its negative relationship with the sector size, which is expressed by the allocation rate and the economic condition of the country (see, inter alia Gwartney et al., 2002; Strauch & Hagen, 2000; Rodrik, 2000 and Mueller, 1997). Thus, the question of the relation between the size of the general government sector and the economy is the subject of verification from the point of view of both stimulant and de-stimulant for extending the size of the general government sector. At the same time, besides the research that is being relatively frequently conducted and dedicated to study interrelations between the size of the general government sector and the economy, there are not many positions in the literature that are devoted to analysis of the inverse relation. This investigation occurs in a relatively small number of research papers, and at the same time only indirectly discusses the author's issues of interest.

Study on the interrelations between the ratios that describe the economy of a particular country and its attributes (including specific characteristics thatindividualize it), and the size of public administration (constituting the component of the general government sector), were undertaken by, among others, Epifani and Ganzi, 2009 (examining the relationship between trade openness and the size of public administration); Rodrik, 1998 and Ruggie, 1982 (who analyzed the relations between open economies and the size of public administration and the sector), as well as Alesina and Wacziarg, 1998 (who investigated the relation between the size of the country (state), and the size of the public sector). The issue of the relation between the economy and the general government sector appeared in the literature also due to the financial crisis. As a result of crises phenomenon, the relations of a state's economic condition and the system of public finance as well as entities of the general government sector that are responsible for its creation, were discussed in the articles slightly more often than in the past. This is reflected inter alia in the papers of the following authors: Działo, 2012; Ainginger, 2011; Creel and Saraceno, 2010; Glassner, 2010; Staehr, 2010; Hon Chu, 2007 and Anwar, 2005.

Regardless of the chosen approaches of variables in studies that determine size of the general government sector, there are attempts made in the literature to resolve universal research problems that are concentrated on the determinants of size of the general government sector. Pevcin, 2004, attempts to identify the determinants of the size of the general government sector, by placing among them factors that have an economic character. On the other hand Wagner, 1883 (as cited in Chobanov & Mladenova, 2009, p. 17), as well as Wilensky, 1964; Holsey and Borcherding, 1997; Persson and Tabellini, 1999 and Boix, 2001, explained that the size of the general government sector is determined by, inter alia, level of economic development of the country (the more developed the country - the greater the size of the general government sector). In parallel, among approaches to research on the relation between the economy and size of the general government sector, there are clearly drawn two positions. The first is based on aggregated demand (see inter alia Peacock & Wiseman, 1961; Berry & Lowery, 1987; Alesina & Perrotti, 1995; Payne, 1991; Rowley & Tollison, 1994; Kraan, 1996 and Kau & Rubin, 2002), and the second is based on aggregated supply (see inter alia Baumol, 1967; Downs, 1967; Niskanen, 1971; Tullock, 1980; Buchanan, 1980 and Mueller, 2003) - as determinants of the sector size. Demand factors explain the size of the sector from the perspective of the social

scale expectations regarding goods supplied and public services. The wider the scale of the society's expectations that is directed to the government (and related to its involvement in fulfillment of social needs), the greater the size of the general government sector. Aggregated demand is thus determinant of the size of the general government sector. Keeping the above issue in mind, it should be noted that this fact is particularly important. The public sector is in fact the largest recipient of goods and services in the economy. Thus, the growth of social expectations regarding the involvement of the state, results in an increase of size of the general government sector. At the same time, the increase in the size of the sector is accompanied by the strengthening of scale and strength of its impact on the economy. This relation suggests that as the size of the general government sector is related to the economy, so the economy and society are in relation to the size of the sector.

The literature reviews which were conducted by the authors for the purpose of this article have not provided conclusive and fully satisfactory results in the area of attempts that were previously undertaken in order to that is directed to the government (and related to its involvement in fulfillment of social needs), the greater the size of the general government sector. Aggregated demand is thus determinant of the size of the general government sector. Keeping the above issue in mind, it should be noted that this fact is particularly important. The public sector is in fact the largest recipient of goods and services in the economy. Thus, the growth of social expectations regarding the involvement of the state, results in an increase of size of the general government sector. At the same time, the increase in the size of the sector is accompanied by the strengthening of scale and strength of its impact on the economy. This relation suggests that as the size of the general government sector is related to the economy, so the economy and society are in relation to the size of the sector.

The literature reviews which were conducted by the authors for the purpose of this article have not provided conclusive and fully satisfactory results in the area of attempts that were previously undertaken in order to explain the issue indicated in the article's title of interrelations on the line: the economy - the size of the general government sector. Considering the above, for the aim of this article the authors decided to identify the most important variables for defining the relation between the economy and the size of the sector as well as to determine the frequency of their occurrence in relation to the studied pairs of variables describing the economy and the size of the general government sector.

Data and methods

The first step of work on this article was to select an object of analysis, i.e. countries that will be used to verify the research objective. It was assumed that the object of analysis will be the economies of the European Union (EU) Member States and their public finance systems. The period selected for the research was 13 years and the authors took into account the years from 2000 to 2013 (inclusive), with the exception of data for the year 2001. Due to the large number of missing data this year was omitted from the analysis. In the next step, the authors designated variables that provide description of the economies of the countries under investigation - EU members. Based on the literature review and the authors' research experience, in order to describe the economy, there were selected 18 variables (see Table 1) and to describe the size of the general government sector 15 variables (see Table 2). The collected statistical data had both a quantitative and qualitative character, and at the same time they took into account the value given in relative and absolute terms. The data was sourced from Eurostat, the Organization for Economic Co-operation and Development (OECD), the International Labour Office (ILO), the United Nations Conference on Trade And Development (UNCTADstat), and the World Bank. Each single variable that was selected for research and that was not present in one of the bases, was supplemented by other database for all EU Member States in the examined period. Due to this fact, in relation to selected variables, the authors were able to keep the time continuity of data describing its values as well as able to maintain cohesion of the data source (data concerning a single variable came from one and the same database throughout the entire period of examination). There is however one fact that should be emphasized - among the measures of the economy (presenting the economic condition of the examined countries), and measures of the size of the general government sector, there were included measures commonly used in the articles devoted to research on economies and public finance systems of the analyzed countries as well as to test the indicators

Table 1. Ratios that describe the economy

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

Source: Own work

Table 2. Ratios that describe size of the general government sector

No	Name	Unit	Data Source
1	General Government gross capital formation (% GDP)	% GDP	Eurostat
2	Government consolidated gross debt (% GDP)	% GDP	Eurostat
3	Public sector employment	Number of people	International Labour Office
4	Total General Government Expenditure (euro per inhabitant)	euro per inhabitant	Eurostat
5	Total General Government Revenue (euro per inhabitant)	euro per inhabitant	Eurostat
6	Net lending/ borrowing	Million Euro	Eurostat
7	Total General Government Expenditure (% GDP)	% GDP	Eurostat
8	Central government deficit (% GDP)	% GDP	Eurostat
9	General Government Sector Output (% GDP)	% GDP	Eurostat
10	Gross value added or General Government total value-added	basic (current) prices	Eurostat
11	The ratio of total taxes to GDP	% GDP	OECD
12	Final consumption expenditure	% GDP	Eurostat
13	General government deficit (% GDP)	% GDP	Eurostat
14	Total General Government Revenue (% GDP)	% GDP	Eurostat
15	General government gross fixed capital formation (% GDP)	% GDP	Eurostat

Source: Own work

Source: Own work

proposed by the authors of this article. Their selection was purposeful and was dedicated to specification of the study design. With this approach it was possible to extend the existing range of analyses on the line: economy - the size of the general government, by new and unexamined pairs of interrelations that explain the relations between the studied attributes of the economy and the sector.

In order to identify the relationships between the economy and the general government sector size, a data mining (commonly known as knowledge discovery in data), process was applied. In general, the process of discovering knowledge in data consists of seven steps: (1) data cleaning which enables the elimination of noises, lacks or errors, (2) data integration where multiple data sources are merged into a single one, (3) data selection where relevant variables are extracted from data, (4) data transformation where transformation or consolidation into appropriate form is required to start data mining, (5) data mining a crucial process where intelligent methods are applied, (6) model validation is utilized to determine that a model is an accurate representation of the real system and (7) knowledge presentation is a visualization technique of the mined knowledge to the user. For our data the first four processes (known as data preprocessing), included:

1) cleaning up the missing attributes/cases. It was assumed that for further research the attributes/cases, in which the number of missing values is less than 1/3 of the total number, were selected. Then, single missing values were completed using advanced methods based on generalized additive models and the method of k-nearest neighbor;

2) integrating data in the form of decision tables. Data from general government sector size and economy domain were placed in separate files split by years. For each year the data were combined in tables consisting of all variables from economy domain and only one decision attribute (called the decision) from general government sector size, located in the rightmost column;

3) selecting data for the countries which are members of the European Union (EU). Identification of the relationships between the economy and the general government sector size was carried out from 2000 to 2013 for 27 member states. Croatia was omitted due to the large number of missing data;

4) transforming data describing continuous attributes. The data were converted to labeled intervals. Two methods of the discretization process were used: equal-width, where the width of the intervals is constant and equal-frequency, where the frequency of instances in the interval is constant. The following numbers of discretization intervals were selected: 4, 6 and 8. Consequently there were 190 decision tables for each discretization interval respectively.

In the next steps of discovering knowledge in data, the data mining process was executed. It is worth mentioning that data mining, model validation and knowledge representation are integrated into one process, referred to as data mining. Taking into account that the main task of data mining is an intelligent data analysis, among the many methods designed for such purpose, Bayesian networks were selected. The choice resulted from the belief that specific properties and advantages of these learning models would allow us to achieve the objective of the research.

Bayesian networks provide the opportunity to explore the causal relationships between variables (Uusitalo, 2007). The graphical nature - directed acyclic graphs whose nodes represent variables and edges encode conditional independencies - of the networks clearly displays the links between variables. Each node is associated with a probability function that takes as input a particular set of values for the node's parent variables and gives the probability of the variable represented by the node. The learning of Bayesian network from data can be categorized as (I) a parameter learning problem when the structure is known, and (II) a structure learning problem when the structure is unknown. In our research we focused on the structure learning problem. Among various methods of structure learning the greedy search was chosen. For a fixed amount of computational time, a greedy search with random restarts produces better models than either simulated annealing or best-first search does (Chickering, 2002). In our approach, Bayesian belief networks are developed with the help of a heuristic algorithm using the Bayesian function of network structure to distribution matching as a scoring function, named K2 (Cooper & Herskovits, 1993; Jensen, 2001). Knowing the constraints of networks learned using the K2 algorithm, we expanded the search

procedure of the algorithm. The process of development of belief networks is steadily controlled by a specific parameter, known as marginal likelihood (ML), informing about the maximum dependence between variables. The calculation of Dirichlet's parameter (DP occurring in the scoring function ML) was favorably optimized by cutting down the number of iteration steps, owing to application of a special algorithm for variable elimination. We generated a set of belief networks for incrementally increased value of DP. In a separate process of global optimization, only distinct networks were kept for further processing. Finally, learning models in the form of Bayesian networks were obtained by applying the greedy algorithm K2 maintaining constant value of a Dirichlet parameter ($\alpha = 50$), established during the previously performed analysis of data sets.

Then the learning models (for 4, 6 and 8 discretization intervals) were tested using 10-fold-cross-validation, which is commonly accepted as a standard way of validating classifiers. In this technique all cases are randomly reordered, and then a set of all cases is divided into ten mutually disjoint subsets of approximately equal size. For each subset, all remaining cases are used for training i.e., for network construction, while the subset is used for testing. Analysis of the 10-fold- cross-validation results indicated that learning models for 4 discretization intervals provided the highest classification efficiency. Thus, to determine the relationships between the economy and the general government sector size, for the future research only the best learning models were used.

Experiments and results

The analysis of the qualitative component (i.e. the graphical structure) of the generated belief networks enabled us to define the relationships between variables describing the mentioned domains. In order to identify the strongest relationship, the most important attributes were considered. The most important attributes in Bayesian networks are the attributes having direct influence on the dependent variable, in our case on the general government sector size (highlighted by red arrows in Figure 1). The frequency of the most significant attribute occurrences in the analyzed networks is presented in Table 3.

Table 3 shows occurrences of the most significant attributes in Bayesian networks which describe relationships between the economy and the general government sector size. According to the results of the calculations, the variable describing the economy which in the period 2000-2013 was the most frequently reported in Bayes networks describing the relationship of the size of general government sector was the parameter that is called gross domestic product in current prices per inhabitant (GDP per inhabitant). In whole period under examination, this parameter occurred in 89 networks showing the relationship of EU Member States with the size of the sector. The second parameter in terms of frequency (in 71 cases), in networks describing the relation of the economy to the size of the general government sector was the variable that is called external balance of goods and services (million euro). Third place was taken by the ratio called balance of the current account (in million euros), which occurred in the 43 Bayesian networks that demonstrated the relation between the economy and the size of the general government sector.

Subsequet positions were taken by the following ratios: FDI - foreign direct investment (million USD) – 39 occurrences in networks, retail sales - dynamic index of turnover (total 2010 = 100) - 37 occurrences, growth rates of GDP (percentage change) – 36 occurrences, as well as inward FDI flows (million USD) – 32 occurrences in Bayes networks and potential output of total economy (million euro) – 30 occurrences. There were some ratios that describe an observed interrelation and that scored below 30 occurrences in the Bayesian network: potential output of total economy (dynamic annual average rate of growth - percentage) – 29 occurrences, as well as gross domestic product in current prices per inhabitant - dynamic (percentage change), activity rate (in %) and real effective exchange rate (index 1999 = 100) –in both case 27 occurrences. Respectively 26 and 23 occurrences in the Bayesian network were observed in relation to the variable called gross capital formation (% GDP) and in the parameter called harmonized indices of consumer prices (HICPs) (annual average rate of change). On the other hand, the variable outward FDI flows (million USD) occurred in 21 networks. There were some measures that scored even worse results: production in industry – dynamic (percentage change compared to the same period in the previous year) – 19 occurrences and

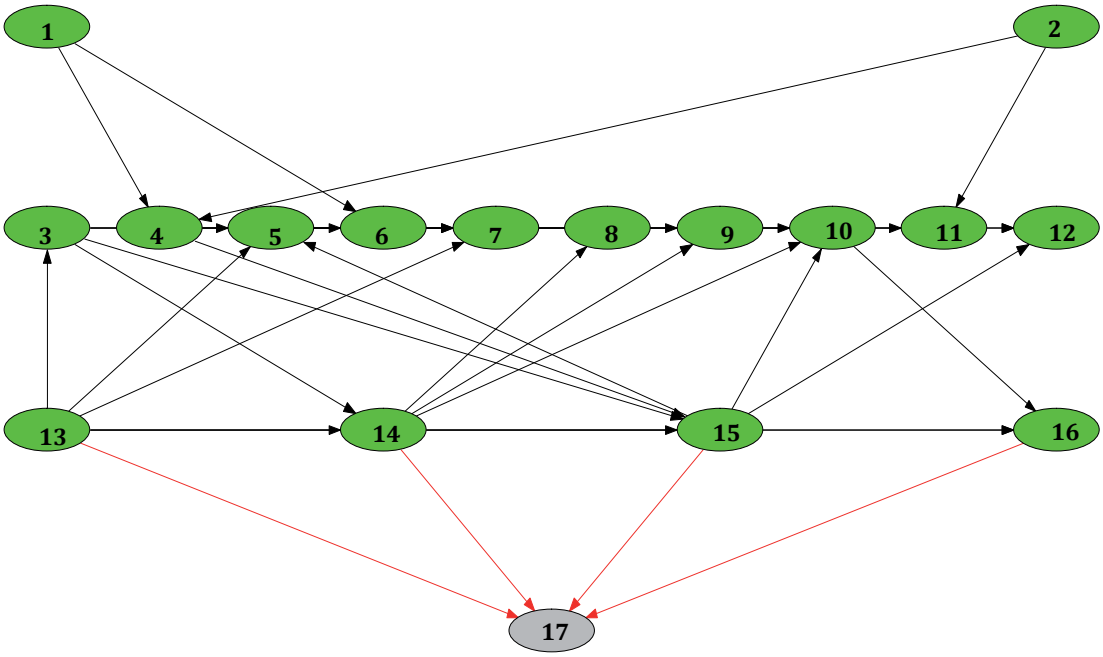

Figure 1. The learning models in the form of Bayesian networks obtained from the BeliefSEEKER system based on the data from 2000 for central government deficit (% GDP)

Key (marking number on the Figure)

(1) Unemployment rate (in %)
(2) Gross capital formation (% GDP)
(3) FDI - Foreign direct investment (Million USD)
(4) Human Development Index – HDI (Value from 0 to 1)
(5) Outward FDI Flows (Million USD)
(6) Gross Domestic Product in current prices per inhabitant - dynamic (Percentage change)
(7) Gross Domestic Product in current prices per inhabitant (GDP per inhabitant)
(8) Production in industry – dynamic (Percentage change compared to same period in previous year)
(9) Real effective exchange rate (Index 1999 = 100)
(10) Balance of the current account (Million Euro)
(11) Potential output of total economy (Million Euro)
(12) Activity rate (in %)
(13) External balance of goods and services (Million Euro)
(14) Harmonised Indices of Consumer Prices (HICPs) (Annual average rate of change)
(15) Inward FDI flows (Million USD)
(16) Growth rates of GDP (Percentage change)
(17) Central government deficit (% GDP)

Source: Own work

unemployment rate (in %) - 17 occurrences in the Bayes network. The ratio that decidedly received the worst result in these comparisons was the human development index – HDI (value from 0 to 1), in relation to which the authors observed only 5 occurrences in the Bayes network which indicates relation between examined variables.

Another dimension of comparative analysis was to examine the scale of the relationships that were identified in relation to a single variable that describes an economy in a cross-section of the particular years under examination. Variables describing the economy which in a section of an individual year under investigation were found with the most frequent occurrences in the Bayesian network were the parameters that are called gross domestic product in current prices per inhabitant (GDP per inhabitant) in year 2005 and external balance of goods and services (million euro) in year 2000. Each of the presented variables occurred in 10 networks in these years. Second place was taken by two ratios ex aequo growth rates of GDP (percentage change) and real effective exchange rate (index 1999 = 100), which respectively in year 2013 and 2006 had 8 occurrences in networks. Based on the criteria, third place was taken by four ratios: balance of the current account (million euro),

FDI - foreign direct investment (million USD), retail sales - dynamic index of turnover (total 2010 = 100) and gross capital formation (% GDP) that respectively in year 2000 (in the case of the first and second variable), 2007(in the case of the third variable) and 2012 (in the case of the fourth variable) occurred in 7 rules that defined the relation between an economy and the government sector's size. There were seven ratios that gained five occurrences in Bayes networks. These were: inward FDI flows (million USD) in year 2012, potential output of total economy (million euro) in year 2000 and 2005, potential output of total economy (dynamic annual average rate of growth - percentage) in year 2010, as well as gross domestic product in current prices per inhabitant - dynamic (percentage change) in year 2004, harmonized indices of consumer prices (HICPs) (annual average rate of change) in year 2013, outward FDI flows (million USD) in year 2000 and unemployment rate (in %) in 2009. In the case of the remaining ratios describing an economy and its relation with the sizes of the general government sector, the frequency of their occurrence in Bayes networks did not exceed 4 cases.

In the next stage of research based on the results obtained using Bayesian networks, it was found which variables describing the economy and the size of the general government sector had a relationship with each other, as well as in how many years this relationship was observed. Presentation of these findings is shown in Table 4. According to these results, the ratio describing an economy which had the strongest relation with variables describing size of the general government sector was the one called gross domestic product in current prices (per inhabitant). This ratio, in the period of 13 years, had a relation with two variables that describe size of the sector: total general government expenditure (euro per inhabitant) and total general government revenue (euro per inhabitant). A slightly smaller stability of relation of the economy's parameters and indicators for the size of the general government sector was distinguished by the ratio called external balance of goods and services (million euro). This ratio in the period of 11 years under investigation showed relation with the same two variables describing the sector's size, ie. total general government expenditure (euro per inhabitant) and total general government revenue (euro per inhabitant). The decidedly weakest result was noted by the ratio of the human development index – HDI (value from 0 to 1), which in only 2 years showed a relation with the variables describing size of the general government sector. The first of them was the ratio of total general government expenditure (% GDP) and the second was the ratio of total taxes to GDP (% GDP).

The most extensive group of relations between the economy and the size of the general government sector, was characterized by three variables. The first of them is the ratio of external balance of goods and services (million euro), the second is gross domestic product in current prices (per inhabitant), and the third is gross domestic product in current prices (per inhabitant) - dynamic (percentage change). All of these variables occurred in relation to 14 out of 15 variables that were included in the analysis describing size of the general government sector. The first of these variables has shown no relations only with the ratio of general government gross fixed capital formation (% GDP). The second variable describing the economy showed no relations only with public sector employment (number of people). The last of these variables showed no relation with the ratio of sector size that is called final consumption expenditure (% GDP).

The next group of variables describing the economy which showed a quite vast scale of relations with variables describing size of the general government sector was formed out of four ratios: balance of the current account (million euro), FDI (foreign direct investment) (million USD), as well as growth rates of GDP (percentage change) and gross capital formation (% GDP). These variables showed relation with 13 parameters describing size of the general government sector. The first mentioned variable showed no relation only with the ratio called net lending/borrowing (million euro) and the ratio of total general government expenditure (% GDP). The second variable describing the economy had no relations with the following: general government gross capital formation (% GDP) and government consolidated gross debt (% GDP). The third mentioned variable describing an economy showed no relation with the ratios of public sector employment (number of people) and general government sector output (% GDP). Finally, the last variable that represented the economy and that occurred in relations to 13 variables describing size of the general government sector showed no relation with the following variables: public sector employment (number of people) and total general government expenditure (euro per inhabitant).

Variables that were ranked in third place (by the number of occurrences) and that described an economy in networks explaining the relation with size of the general government sector were the variables that occurred in ranking 12 times. It means that the variables that describe an economy occurred in relation to 12 out of 15 of the examined variables describing size of the general government sector. In this group, there were the following variables: production in industry – dynamic (percentage change compared to same period in previous year), real effective exchange rate (index 1999 = 100), as well as retail sales - dynamic (index of turnover – total 2010 = 100) and potential output of total economy - dynamic (annual average rate of growth - percentage). The first of them remained neutral with the following variables: general government gross capital formation (% GDP), public sector employment (number of people) and total general government revenue (euro per inhabitant). The second variable that describes an economy showed no relations with the following variables describing size of the general government sector: government consolidated gross debt (% GDP), total general government revenue (euro per inhabitant), as well as the ratio of total taxes to GDP (% GDP). The third variable that presented an economy remained neutral with the following variables presenting size of the sector: public sector employment (number of people), total general government expenditure (euro per inhabitant) and total general government revenue (euro per inhabitant). Finally, the last variable on the economy side, remained in no correlation with the following variables describing size of the general government sector: total general government revenue (euro per inhabitant), as well as final consumption expenditure (% GDP) and total general government revenue (% GDP).

The ratio human development index – HDI (value from 0 to 1), which showed no relations with 12 variables explaining size of the sector, was the one that had the weakest score in the comparisons on a scale of relations between a variable describing an economy and a variable describing size of the general government sector. On the next position of this ranking were the following variables: outward FDI flows (million USD) – no relation with 8 variables describing size of the general government sector, as well as potential output of total economy (million euro) and harmonized indices of consumer prices (HICPs) (annual average rate of change) – that showed no relation with 5 variables describing size of the general government sector.

Discussion

This study provided a way to answer questions that were dedicated to the field of public finance and that brought up a set of interesting issues. First of all, the research provided a creation of a ranking of the maximum number of occurrences for variables that describe an economy in Bayes networks (describing a relation of an economy to the size of the general government sector) in the examined period 2000-2013 (see Table 5). Variables that described an economy and which occur in the largest number of networks explaining relation with the size of the general government sector were: gross domestic product in current prices per inhabitant (GDP per inhabitant) and external balance of goods and services (million euro). The first occurred in 89 networks, whereas the second occurred in 71 networks. In the next places there were listed: balance of the current account (million euro) – 43 occurrences, FDI - foreign direct investment (million USD) – 39 occurrences, retail sales - dynamic index of turnover (total 2010 = 100) – 37 occurrences, as well as growth rates of GDP (percentage change) – 36 occurrences in networks describing relation with size of the general government sector. Variables that described an economy that were characterized by the smallest number of occurrences in Bayes network describing their relation with size of the general government sector, were variables called production in industry – dynamic (percentage change compared to the same period in previous year) – 19 occurrences, unemployment rate (in %) – 17 occurrences and human development index – HDI (value from 0 to 1), in relation to which the authors found only 5 occurrences in networks describing a relation with the economy.

Secondly, the study allowed preparation of a ranking of the variables describing the economy, which was based on the number of compounds of a single economic variable with a variable presenting size of the general government sector (see Table 6). Therefore, the ranking provided a chance to determine an answer to the question of the number of relations that were identified in reference to a single variable that describes an economy with an individual variable describing size of the general government sector in the cross-section of a single year of examination. The highest number of relations (throughout the analyzed period), with the variables describing size of general government sector was found ex aequo by the two variables of gross domestic product in current

prices per inhabitant (GDP per inhabitant) and external balance of goods and services (million euro), in relation to which there were 10 occurrences identified. Subsequent places were taken by growth rates of GDP (percentage change) and real effective exchange rate (index 1999 = 100) –equally 8 occurrences and balance of the current account (million euro), FDI - foreign direct investment (million USD), retail sales - dynamic index of turnover (total 2010 = 100), and gross capital formation (% GDP) –7 occurrences. The decidedly weakest result was achieved by the variables: activity rate (in %), production in industry – dynamic (percentage change compared to same period in previous year) and human development index – HDI (value from 0 to 1). In relation to the first two variables, the authors noticed 4 occurrences in Bayesian networks describing a relation of the economy and the sector. In relation to the last among variables on the economy's side, i.e. HDI, there were only 2 occurrences (which means that the variable called human development index in a single examined year occurred in a maximum 2 relations with variables describing the size of the sector).

Thirdly, as a result of the research the authors determined which of the variables describing an economy and which from the variables describing size of the general government sector show the highest frequency of relations (counted in number of years), when interrelations between pairs of these variables were identified (see Table 7). According to the results, the variable called gross domestic product in current prices (per inhabitant) that describes an economy remained in the entire examined period (i.e. 13 years) in relation with the variables of total general government expenditure (euro per inhabitant) and total general government revenue (euro per inhabitant) describing size of the general government sector. Relation with variables called total general government expenditure (euro per inhabitant) and total general government revenue (euro per inhabitant), was also shown by other economy-describing ratio, i.e. external balance of goods and services (million euro), and the identified interrelation was maintained in 11 out of 13 years under examination. In 9 out of 13 investigated years, the interrelation was confirmed by two more variables, i.e. activity rate (in %) – on the economy side, and public sector employment (number of people) on the side of the sector. The authors confirmed that the interrelation exists between the ratio inward FDI flows (million USD), and the variable total general government revenue (euro per inhabitant) in the period of 8 years.

In 7 years within the investigated period, the authors identified a relation between the potential output of total economy (million euro) describing an economy and the variable net lending/ borrowing (million euro) describing size of the general government sector. For 7 years, there was also interrelation between the following variables: FDI (foreign direct investment) (million USD) – on the economy's side and total general government revenue (euro per inhabitant), as well as ratio general government sector output (% GDP) on the side of the sector. Similarly for 7 years, the authors identified a relation between potential output of total economy - dynamic (annual average rate of growth - percentage), i.e. a variable describing an economy and general government deficit (% GDP), i.e. a ratio that presents size of the sector. The next variable that describes the economy- balance of the current account (million euro), confirmed relation with the following variables describing size of the general government sector: total general government expenditure (euro per inhabitant), public sector employment (number of people) and general government gross capital formation (% GDP), for a period of 6 years. In 6 out of 13 of the examined years, there was also relation between the other two pair of variables, i.e. outward FDI flows (million USD) and total general government revenue (euro per inhabitant), as well as growth rates of GDP (percentage change) and total general government revenue (% GDP). The next examined pair of variables had only a one year shorter period of its relations. Relation of ratio gross domestic product in current prices (per inhabitant) - dynamic (percentage change) and total general government revenue (% GDP) was found in 5 examined years, similarly to interrelation between retail sales - dynamic (index of turnover – total 2010 = 100) a general government gross capital formation (% GDP) and between retail sales - dynamic (index of turnover – total 2010 = 100) and variable gross value added (general government total value-added) (basic (current) prices). During the four years from within the whole investigated period, the following pairs of interrelations were found: the ratio gross capital formation (% GDP) – on the side of variables that represent an economy and the variable called total general government expenditure (% GDP) – on the side of variables that represent size of the general government sector. There was also relation of ratio called harmonized indices of consumer prices (HICPs) (annual average rate of change) with variables presenting size of sector that are the following: general government gross fixed capital formation (% GDP),

total general government revenue (% GDP) and total general government expenditure (% GDP). Finally, in 4 out of 13 of the examined years, the authors found interrelation between real effective exchange rate (index 1999 = 100),and three other ratios that describe size of the general government sector. These were, among others, total general government revenue (% GDP), gross value added (general government total value-added) (basic (current) prices) and central government deficit (% GDP). In the whole examined period, the variable human development index – HDI (value from 0 to 1) was characterized by the decidedly smallest frequency of relations. It showed interrelations in only 2 out of 13 years. The ratios that it was interrelated with were general government sector, i.e. total general government expenditure (% GDP) and the ratio of total taxes to GDP (% GDP). There were two ratios, which describe an economy, i.e. production in industry – dynamic (percentage change compared to same period in previous year) and unemployment rate (in %) that closed the ranking with only slightly better results. The interrelation of these two with a variable called general government sector was identified in only 3 out of 13 of the examined years. In the period of examination, the first of these ratios had a relation with two variables that describe size of the sector, i.e. general government sector output (% GDP) and general government gross fixed capital formation (% GDP), whereas the second ratio that presented the economy, corresponded only with one variable on the sector's side, i.e. government consolidated gross debt (% GDP).

Fourthly, the research provided a creation of a ranking of variables that present an economy by the number of their occurrences in the Bayes networks, which describe relations with size of the general government sector (see Table 8). Because of that, it was possible to find the answer to a question about the number of relations with parameters describing an economy that were correlated with 15 examined variables describing size of the general government sector in Bayes networks. Basing on the prepared ranking, the authors found that the variables which describe an economy and which showed relation with all 15 variables describing size of the general government sector, were: external balance of goods and services (million euro), human development index – HDI (value from 0 to 1) and outward FDI flows (million USD). An equally high result was identified in relation to four other variables that describe an economy, i.e. potential output of total economy (million euro), inward FDI flows (million USD). Third place was taken by three variables: balance of the current account (million euro), potential output of total economy (million euro) and activity rate (in %). Another group was created by variables which took fourth place, i.e. ratios that can be used to explain relations between economy and size of the sector to a somewhat smaller extent. To this group we can assign ratios growth rates of GDP (percentage change), retail sales - dynamic index of turnover (total 2010 = 100) and ratio potential output of total economy (dynamic annual average rate of growth - percentage). In the fifth place, there were ex aequo outward FDI flows (million USD) and gross domestic product in current prices per inhabitant - dynamic (percentage change). Variables which in sixth place and due to that fact were qualified to explain relations between an economy and size of the general government sector to an even lesser extent, were: real effective exchange rate (index 1999 = 100), as well as gross capital formation (% GDP). Second to last, seventh place was taken by the variable: harmonized indices of consumer prices (HICPs) (annual average rate of change), and the last, eighth place, were taken by three variables describing an economy which showed the smallest potential to explain the relation between an economy and size of the general government sector. These were the following ratios that illustrate economies of EU Member States under examination: unemployment rate (in %), as well as production in industry – dynamic (percentage change compared to same period in previous year) and human development index – HDI (value from 0 to 1).

Conclusion

The research proved that Bayesian networks can successfully be used in analyses which are dedicated to examining the relationship of an economy and the size of the general government sector. The applied methodology allowed us not only to identify relationships between economic variables and variables describing the sector, but also provided an answer to the question of which variables remained together in relationships and how long this relationship was maintained during the examined period. On the basis of this analysis, the authors determined that two economic variables that were *ex aequo* and by far to the greatest degree classified to analyze the relationship on the line economy - the size of the sector, were the ratios external balance of goods and services and gross domestic product in current prices

per inhabitant. The next economic variables that according to this methodology were found as the best in explanation of a relationship between an economy and the size of the general government sector were (again *ex aeuqo*), two variables foreign direct investment (FDI) and inward FDI flows. The last ratios in the top 3 of this classification were the ones called: balance of the current account, potential output of total economy and activity rate. This classification of variables is interesting, because of at least couple of reasons. First of all, the research showed that relations between the size of national general government sector was identified in the case of not only parameters describing economies of EU member states as the closed economies, but also presenting them as open economies (including import and export). Secondly, the conclusion from the previous point is confirmed by the observation according to which a very important role in explanation of the relationship between the economy and the size of the general government sector is played by foreign direct investment, and especially inward FDI flows. Finally, thirdly, the lowest "effectiveness" in explaining the researched relationships is found in the case of human development index, which is a synthetic measure of the socio-economic development degree of a country. According to the conducted study, the level of socio-economic development is not the best variable that qualifies for explaining the relationship between an economy and the size of the general government sector. The examined parameter was found with the lowest frequency of relationships, as well as a lack of their continuity. As a result, although HDI is theoretically a variable that synthetically reflects the state of the economy – it is not eligible to clarify relationships on the line: the economy - the size of the general government sector.

Table 3. Occurrences of the most significant attributes in Bayesian networks that describe the relationships between the economy and the general government sector size

Parameters describing relations between economy and size of general government sector	2000	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
External balance of goods and services (Million Euro)	10	5	5	3	4	4	8	4	6	9	5	2	5
Gross Domestic Product in current prices per inhabitant (GDP per inhabitant)	8	9	6	5	10	7	7	7	8	8	7	3	4
Production in industry – dynamic (Percentage change compared to same period in previous year)	4	1	4	-	3	-	2	-	-	1	2	2	-
Balance of the current account (Million Euro)	7	4	3	4	6	3	3	3	3	-	4	1	2
Potential output of total economy (Million Euro)	5	2	2	2	5	4	1	1	-	2	-	4	2
Harmonized Indices of Consumer Prices (HICPs) (Annual average rate of change)	1	1	1	-	-	3	1	3	1	-	4	3	5
Inward FDI flows (Million USD)	4	4	3	1	2	2	2	3	1	1	4	5	-
FDI - Foreign direct investment (Million USD)	7	2	1	2	3	1	1	2	4	3	3	5	5
Real effective exchange rate (Index 1999 = 100)	2	2	1	3	1	8	2	2	2	2	1	-	1
Human Development Index – HDI (Value from 0 to 1)	1	-	-	-	-	-	-	2	-	-	-	2	-
Outward FDI flows (Million USD)	5	1	2	1	1	2	1	1	2	2	2	1	-
Growth rates of GDP (Percentage change)	1	3	3	5	2	3	2		1	4	2	2	8
Gross capital formation (% GDP)	2	1	-	-	2	1	3	5	2	-	3	7	-
Gross Domestic Product in current prices per inhabitant - dynamic (Percentage change)	1	2	3	5	-	2	3	1	1	3	4	2	-
Activity rate (in %)	1	3	3	4	1	2	2	2	3	-	2	2	2
Retail sales - dynamic Index of turnover (Total 2010 = 100)	-	1	1	2	6	1	7	2	3	4	3	3	4
Potential output of total economy (Dynamic Annual average rate of growth - percentage)	-	1	3	3	1	3	2	3	3	5	2	2	1
Unemployment rate (in %)	-	1	-	1	-	-	1	4	5	1	2	2	-

Source: Own work

Table 4. Combination that presents relations between variables describing economy and individual variables describing sizes of general government sector in the period of 2000-2013 (number in bracket states for number of years in analyzed period, where the relation between the variables was identified)

	General Government gross capital formation (% GDP)	Government consolidated gross debt (% GDP)	Public sector employment (Number of people)	Total General Government Expenditure (Euro per inhabitant)	Total General Government Revenue (Euro per inhabitant)	Net lending/ borrowing (Million Euro)	Total General Government Expenditure (% GDP)	Central government deficit (% GDP)	General Government Sector Output (% GDP)	Gross value added (General Government total value-added) (Basic (current) prices)	The ratio of total taxes to GDP (% GDP)	Final consumption expenditure (% GDP)	General government deficit (% GDP)	Total General Government Revenue (% GDP)	General government gross fixed capital formation (% GDP)
External balance of goods and services (Million euro)	1	2	1	11	11	6	4	6	3	2	4	8	7	5	
Gross Domestic Product in current prices (per inhabitant)	4	6		13	13	3	7	2	8	2	10	7	2	9	3
Production in industry – dynamic (Percentage change compared to same period in previous year)		2		1		1	1	2	3	1	1	1	2	1	3
Balance of the current account (Million euro)	6	2	6	6	5			3	2	1	3	1	1	4	4
Potential output of total economy (Million euro)		2	3			7	2	1	1	4	1			1	1
Harmonized Indices of Consumer Prices (HICPs) (Annual average rate of change)	2		1			2	4			1	2	1	2	4	4
Inward FDI flows (Million USD)	2	2	6	2	8		1		3		4	2		1	1
FDI (Foreign direct investment) (Million USD)			2	4	7	2	3	1	7	2	4	1	2	3	1
Real effective exchange rate (Index 1999 = 100)	2		2	1		1	1	4	2	4		2	2	4	2
Human Development Index – HDI (Value from 0 to 1)							2	1			2				
Outward FDI flows (Million USD)		1	4	3	6		1				2	3			
Growth rates of GDP (Percentage change)	2	4		2	2	2	4	4		2	2	1	2	6	3
Gross capital formation (% GDP)	2	1			1	2	4	3	2	1	3	3	2	1	2
Gross Domestic Product in current prices (per inhabitant) - dynamic (Percentage change)	1	4	2	1	2	1	2	2	2	1	1		1	5	2
Activity rate (in %)	2	2	9	2	1	2		3	1			2	1		2
Retail sales - dynamic (Index of turnover – Total 2010 = 100)	5	2				2	3	3	2	5	1	4	2	4	4
Potential output of total economy - dynamic (Annual average rate of growth - percentage)	6	2	2	1		1	1	4	3	1	4		7		4
Unemployment rate (in %)	1	3			1	2	1	1	1	2	2		2		1

Source: Own work

Table 6. Ranking by number of relations identified by reference to individual variable that describe economy with a variable describing size of the general government sector in the period 2000-2013 (inclusive)

Lp	Variable Name	Value
1	Gross Domestic Product in current prices per inhabitant (GDP per inhabitant)	10
	External balance of goods and services (Million Euro)	10
2	Growth rates of GDP (Percentage change)	8
	Real effective exchange rate (Index 1999 = 100)	8
3	Balance of the current account (Million Euro)	7
	FDI - Foreign direct investment (Million USD)	7
	Retail sales - dynamic Index of turnover (Total 2010 = 100)	7
	Gross capital formation (% GDP)	7
4	Inward FDI flows (Million USD)	5
	Potential output of total economy (Million Euro)	5
	Potential output of total economy (Dynamic Annual average rate of growth - percentage)	5
	Gross Domestic Product in current prices per inhabitant - dynamic (Percentage change)	5
	Harmonised Indices of Consumer Prices (HICPs) (Annual average rate of change)	5
	Outward FDI flows (Million USD)	5
	Unemployment rate (in %)	5
5	Activity rate (in %)	4
	Production in industry – dynamic (Percentage change compared to same period in previous year)	4
6	Human Development Index – HDI (Value from 0 to 1)	2

Source: Own work

Table 7. Ranking by number of years, when authors identified relations between the variable describing economy and variable describing size of general government sector in period 2000-2013 (inclusive)

No	Name of variable describing economy	Name of variable describing size of general government sector	Number of years, when authors identified relations between variable describing economy, and variable describing size of general government sector
1	Gross Domestic Product in current prices (per inhabitant)	Total General Government Expenditure (Euro per inhabitant)	13
		Total General Government Revenue (Euro per inhabitant)	13
2	External balance of goods and services (Million euro)	Total General Government Expenditure (Euro per inhabitant)	11
		Total General Government Revenue (Euro per inhabitant)	11
3	Activity rate (in %)	Public sector employment (Number of people)	9
4	Inward FDI flows (Million USD)	Total General Government Revenue (Euro per inhabitant)	8
5	Potential output of total economy (Million euro)	Net lending/ borrowing (Million Euro)	7
6	FDI (Foreign direct investment) (Million USD)	Total General Government Revenue (Euro per inhabitant)	7
		General Government Sector Output (% GDP)	7
7	Potential output of total economy - dynamic (Annual average rate of growth - percentage)	General government deficit (% GDP)	7
8	Balance of the current account (Million euro)	Total General Government Expenditure (Euro per inhabitant)	6
		Public sector employment (Number of people)	6
		General Government gross capital formation (% GDP)	6
9	Outward FDI flows (Million USD)	Total General Government Revenue (Euro per inhabitant)	6
10	Growth rates of GDP (Percentage change)	Total General Government Revenue (% GDP)	6
11	Gross Domestic Product in current prices (per inhabitant) - dynamic (Percentage change)	Total General Government Revenue (% GDP)	5

No	Name of variable describing economy	Name of variable describing size of general government sector	Number of years, when authors identified relations between variable describing economy, and variable describing size of general government sector
12	Retail sales - dynamic (Index of turnover – Total 2010 = 100)	General Government gross capital formation (% GDP)	5
		Gross value added (General Government total value-added) (Basic (current) prices)	5
13	Gross capital formation (% GDP)	Total General Government Expenditure (% GDP)	4
14	Harmonised Indices of Consumer Prices (HICPs) (Annual average rate of change)	General government gross fixed capital formation (% GDP)	4
		Total General Government Revenue (% GDP)	4
		Total General Government Expenditure (% GDP)	4
15	Real effective exchange rate (Index 1999 = 100)	Total General Government Revenue (% GDP)	4
		Gross value added (General Government total value-added) (Basic (current) prices)	4
		Central government deficit (% GDP)	4
16	Production in industry – dynamic (Percentage change compared to same period in previous year)	General Government Sector Output (% GDP)	3
		General government gross fixed capital formation (% GDP)	3
17	Unemployment rate (in %)	Government consolidated gross debt (% GDP)	3
18	Human Development Index – HDI (Value from 0 to 1)	Total General Government Expenditure (% GDP)	2
		The ratio of total taxes to GDP (% GDP)	2

Source: Own work

Table 6. Ranking by number of occurrences of variables describing an economy in a Bayes network that describe relations between general government sector in the period 2000-2013 (inclusive)

No	Variable Name	Number of occurrences (Total number of variables that describe size of public finance sector = 15)
1	External balance of goods and services (Million euro)	15
	Human Development Index – HDI (Value from 0 to 1)	15
	Outward FDI flows (Million USD)	15
2	Potential output of total economy (Million euro)	14
	Inward FDI flows (Million USD)	14
	FDI (Foreign direct investment) (Million USD)	14
	Unemployment rate (in %)	14
3	Real effective exchange rate (Index 1999 = 100)	13
	Gross capital formation (% GDP)	13
	Gross Domestic Product in current prices (per inhabitant) - dynamic (Percentage change)	13
	Activity rate (in %)	13
4	Gross Domestic Product in current prices (per inhabitant)	12
	Production in industry – dynamic (Percentage change compared to same period in previous year)	12
	Growth rates of GDP (Percentage change)	12
5	Balance of the current account (Million euro)	11
	Harmonised Indices of Consumer Prices (HICPs) (Annual average rate of change)	11
	Retail sales - dynamic (Index of turnover – Total 2010 = 100)	11
	Potential output of total economy - dynamic (Annual average rate of growth - percentage)	11

Source: Own work

Table 9. Classification of variables that describe an economy and demonstrates "the strongest" relations with a variable describing size of the general government sector by criteria of average ranking position of each variable in individual ranking lists

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

Ranking 1.Ranking by maximum number of occurrences of variable describing an economy in the Bayes network that describe size of the general government sector in the period 2000-2013 (inclusive)
Ranking 2.Ranking by number of relations identified by reference to an individual variable that describes an economy with a variable describing size of the general government sector in the period 2000-2013 (inclusive)
Ranking 3. Ranking by number of years, when authors identified relations between the variable describing an economy and variable describing the size of general government sector in period 2000-2013 (inclusive)
Ranking 4.Ranking by number of occurrences of variable describing an economy in the Bayes network that describes relations between general government sector in the period 2000-2013 (inclusive)

Source: Own work

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