MANAGEMENT OF RESEARCH AND DEVELOPMENT ACTIVITIES IN THE CONTEXT OF STRATEGY EUROPE 2020

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Abstract: The aim of the article is to evaluate the current situation of research and development management in the view of the fulfillment of the strategy of Europe 2020 by Poland and Slovakia and, based on the results of analysis, to predict the expected development of the indicator by 2020 and assesses the reaching their national targets in monitored area. Regression analysis is used to estimate the trends feature for predicting the expected development of the indicator expressing the share of expenditure on R&D of GDP in 2020. To describe and evaluate the development of monitored indicator during the 11 or 22 years period, we are using trend comparison. Based on the stated results it is possible to determine the predicted values of the indicator in the future and then evaluate whether that country will manage to achieve its set target by 2020.

Keywords: management, target, strategy Europe 2020, research, expected development

Introduction

The area of research, development and innovation has in recent years been regarded as the engine for the economic growth of the economies of the industrial countries of the world (Foray et al., 2011; Grabara and Manole, 2017; Zimon, 2018). Innovations are created mostly within the trade sphere where the trade subjects compete to keep their position. The results from the research, development, new information, knowledge and skills have played an important role in recent years (Pacana et al., 2014; Malindzak et al., 2017; Pacana et al., 2016). This period is characterized by its transition from the 'old' type to the 'new' type of information based economics, where the economic development is supported through knowledge and there is an implementation of new information obtained by research and development (Soriano and Mulatero, 2010). The EU and its member states present a great potential for innovation. Despite individual member states of the European Union wielding great intellectual potential, most of them do not

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command sufficient financial means to enable the research and development needed to create innovations to be introduced onto the market. The lack of finance shows predominantly in the tertiary area of science, research and development, and also in the individual companies able to innovate and improve production into practice. (Mahmud et al., 2017)

Theoretical Framework

The management of research and development activities is a key factor allowing achievement of future growth of the enterprise as they are eventually leading toward an increase of the knowledge, a better technology capacities and products and processes innovation, which is transformed into the innovative performance of the country (Natali, 2010; Lundvall and Lorenz, 2011; Kasza, 2009).

The importance of the research and development is underlined also in Strategy Europe 2020 which is an economic plan of European Union to obtain intelligent, sustainable and inclusive growth (European Commission, 2014 and 2019). Within this strategy the Union marked five targets (in the area of employment, research and development, education, climate changes and energy sustainability, poverty and social exclusion) from which the research and development is the object of our research. As for the validity and importance of defined objectives of the strategy Europe 2020, they are criticized and their mutual interdependence is discussed. The issue of the feasibility of achieving the objectives dealt Colak and Ege (2011) but also Leschke, Theodoropoulou, Watt (2012). Their approaches are different. Colak and Ege (2011) developed their own composite indices observing the performances of member and candidate countries in a single indicator for overall strategy and for each priority of growth. Their results point out strong leadership Nordic EU countries in almost every study area, but especially in the field of R&D. Rappai (2016) proposes new, more effective comprehensive index, which measures how close are the Member States to achieve the targets, even with regards to the diversity of growth rates of individual countries. (Grzebyk and Stec, 2015)

Implementing and managing R&D activities within business allow creating an environment within organization favourable to questioning the processes and products, encouraging therefore company's flexibility and its ability to integrate new concepts and processes. Hence, it will allow company to adapt itself in an efficient way to market changes (Freel, 2000). The development of innovation and technology is considered as the most important factor of competitiveness and the most effective means to meet its objectives (Dino and Sánchez, 2017). R&D and innovation are the main source of long-term profits, business success and competitive advantage. Human capital also has a significant impact on these activities, especially from the point of view of its abilities, educational level (Olexová, 2018). The basis of success is to know the market and its customers. However, the research, development and innovation activities do not bring value only for customers but also for company shareholders, managers, employees, entire company and thus for society as a whole. Only the balance of these values gives a

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chance for long-term success (Strielkowski and Čábelková, 2016; Marlier and Natali, 2010; Quental et al., 2011).

For the purposes of this article, the most important target is in the area of R&D - to increase expenditure on R&D by 2020 to 3% of GDP on average for the EU.

Methodology

During processing article were in addition to standard logic methods intended for processing data (methods of acquisition and data collection, analysis) and drawing conclusions (synthesis, induction) used mathematical and statistical methods (regression analysis). Regression analysis was used to estimate the trends feature for predicting the expected development of the indicator expressing the share of expenditure on R&D of GDP in 2020. Among the many variants of functions describing the present trend in the indicator was voted best statistically significant model. The suitability of trend function is checked by the Coefficient of Determination (R^2), F test and the P-value. P-value assesses the significance of individual regression coefficients. While R^2 provides an estimate of the strength of the relationship between proposed model and the response variable, it does not provide a formal hypothesis test for this relationship. The overall F-test determines whether this relationship is statistically significant. In case that two or more of tested models is statistically significant, we select one with the higher R^2. Used functions have the following mathematical descriptions (Tab.1).

Table 1. Functions and their mathematical description

Function	Mathematical description
Linear	$y'_j = b_0 + b_1 x_j$
2nd order polynomial	$y'_j = b_0 + b_1 x_j + b_2^2 x_j^2$
Logarithmic	$y'_j = b_0 + \ln x_j$
Exponential	$y'_j = b_0 \cdot b_1^{x_j}$
Power	$y'_j = b_0 \cdot x_j^{b_1}$
Where: b_0 - constant, b_1, b_2 - the regression coefficient, y_j - the value of the dependent variable, x_j – the value of the independent variable	

Another used method was the comparative method - spatial comparison for comparison of selected indicators in Slovakia and Poland and trend comparison for examination the development of the indicators over time.

All results of the analysis in the form of graphs and tables have been processed in Microsoft Office Excel. In the article it was used the latest available data published in database of the EU statistical office (Eurostat) on the date 25.01.2019.

Financing of Research and Development in Slovakia and Poland

One of the main elements of R&D management involves overseeing, managing and allocating the budget assigned to given research projects. On the national level, the question of the financing of R&D activities is reflected in the indicator expressing the share of gross domestic expenditure on R&D of GDP of the country (GERD). This ratio indicator is used to monitor the fulfilment of one of the targets of the strategy Europe 2020 - to increase the expenditure on R&D in the European Union to 3% of GDP by 2020.

The set target of the Strategy includes a partial target regarding the structure of the expenditure on R&D. According to this sub-target, 1/3 of expenditure should come from the government sector and 2/3 of expenditure on R&D activities should consist of expenditure from the business sector.

Based on the last available data from the Eurostat, in 2016 the first five countries with the highest value of expenditure on R&D of GDP are Sweden, Austria, Germany, Denmark and Finland. On the other side, the lowest share on the expenditure on R&D of GDP in 2016 was recorded mostly among the southern states of the European Union, for example Cyprus, Romania, Malta and also Latvia (Fig. 1).
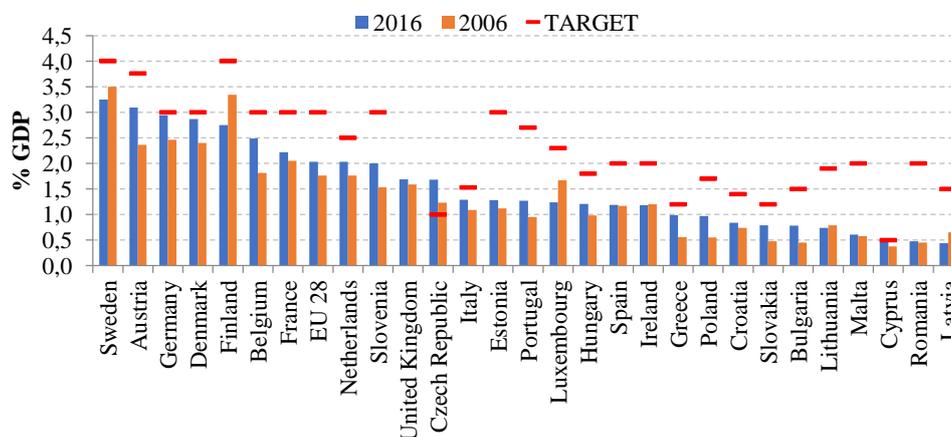

Figure 1. Expenditure on R&D in the member states of the EU in 2006 and 2016 compared with the target values

As it is depicted, six countries have the target of increasing their share of expenditure on R&D of GDP by 2020 at 3%, three countries (Finland, Sweden and Austria) have set it even more even more than 3%. In 2016, none of the European Union's Member States reached the target value in the monitored area (in 2015 Denmark exceeded its target value in 2015 by 0.03%). In 2015 was Slovakia behind its target only by 0.02%, in 2016 it was 0.41%. To the contrary, Romania, Estonia and Portugal are the most behind their national target in the area of R&D (Estonia by 1.72%, Romania by 1.52% and Portugal by 1.43%). Significantly unfavourable indicator developments can be observed in Finland, where the share of R&D expenditure on GDP is decreasing and the country is shifting and lagging

behind the target value 4%. Basic descriptive statistics for the monitored indicator for the period of 22 years for both compared countries is in table 2. It has the corresponding Box Plot (Fig. 2). Based on this, it can be established that the greatest variability of a indicator's changes is in the Slovakia with also higher average value.

The economic crisis as the consequence of the mortgage crisis in the USA influenced most EU countries in a very negative way. Its impact was demonstrated by a fall in elementary macroeconomic qualities. The level of the financing of R&D activities in Slovakia was the lowest in comparison with the other countries of the V4 despite that their amount raised 6.7 times during 1995-2015. Last monitored year, amount of financial resources significantly decreased from 927 mill. € to 640 mill. €. This was due to a significant year-on-year decrease in the use of financial resources from the European Union funds, in particular under the Operational Program Research and Innovation. The country attains the lower average value and also the lower spread of indicator changes.

Table 2. Descriptive statistic for the share of GERD

	PL	SK
Count	22	22
Minimum	0.5400	0.4500
Maximum	1.0000	1.1800
Mean	0.6914	0.6936
Median	0.6400	0.6450
Stand. Dev.	0.1463	0.2030
Confidence Level (95,0%)	0.0649	0.0900
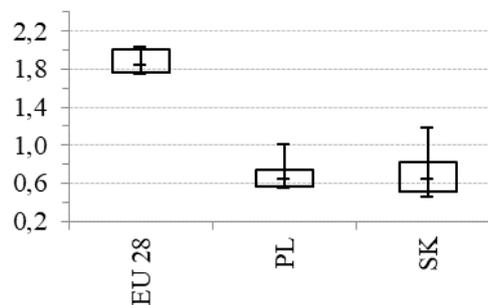
Figure 2. BoxPlot for the share of GERD (% of GDP)

In Poland the sum of expenditure increased 6.1 times during twenty years (from 0.67 billion € to 4.1 billion €). Country has recorded the larger spread of changes and the higher average value of the monitored indicator from a group of V4 (Fig. 3a, Tab. 3a).
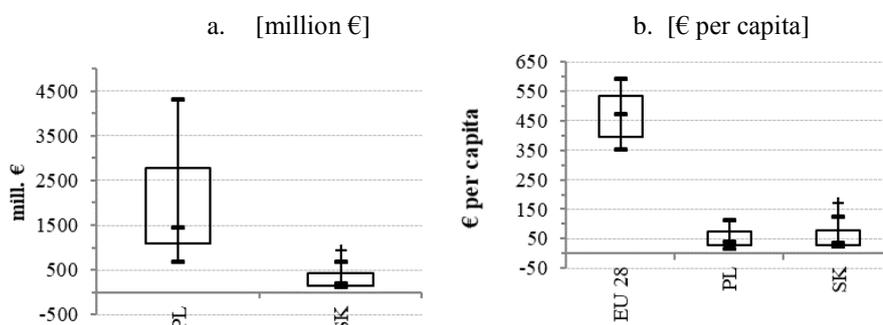
Figure 3. BoxPlot for the amount of expenditure on R&D in compared countries

The absolute amount of investment was changing from the start of the independent republic. Also the indicator value for the share of GERD to GDP was changing. In 1993 the indicator's value achieved 1.38% GDP which represented the highest value from the division of Czechoslovakia until now. Those days the size of the investment was 157.144 million €. The relative indicator reached its lowest value in 2007 at the onset of the mortgage crisis in the USA, the 0.45% of GDP. A moderate increase happened in recent years when the R&D activates started to be considered as one of the decisive solutions from the then ongoing economic crisis. Except for the growing expenditure from the state budget for the support of such activities, the finances from the structural funds of the EU were being intensively used, which had a positive effect on its increase to 1.18% of GDP (in 2015).

Table 3. Descriptive statistic for the indicator of expenditure on R&D

	a. [million €]		b. [€ per capita]	
	PL	SK	PL	SK
Count	22	22	22	22
Minimum	672.702	125.831	17.400	23.300
Maximum	4316.508	927.272	113.600	171.00
Mean	1996.087	324.907	52.346	60.196
Median	1449.112	209.875	37.950	39.050
Stand. Dev.	1171.724	227.309	30.935	41.865
Conf. Lev. (95%)	519.513	100.783	13.716	18.562

We think that the indicator expressing the amount of expenditure (on R&D activities) per capita is most important. The expenditure per capita in Slovakia and in Poland was developing for many years approximately in the same way. Changes only occurred during recent years. In Slovakia it increased from 25.8 € to 171.0 € (in 2015) and then decreased to 118.1 € in 2016. In Poland expenditure increased during the 22 years from 17.4 € to 108.3 € per capita. It also showed a lesser spread

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of change (Fig. 3b, Tab. 3b). This expenditure are well below the average expenditure of the European Union (592.3 €).

Discussion

It is possible to use various functions to describe the current trend in the development of indicators expressing the share of expenditure on R&D compared to GDP in Slovakia and Poland (Tab. 4).

Table 4.1 Expected development of the expenditure on R&D (% of GDP)

	Trend	Function	R^2
PL	Linear	$y= 0.0159x + 0.5084$	0.4982
	Exponential	$y= 0.5342e^{0.0207x}$	0.4633
	Polynomial 2nd degree	$\mathbf{y= 0.0025x^2-0.0419x+0.7398}$	**0.8968**
	Polynomial 3rd degree	$y= 7E\text{-}05x^3 + 0.0003x^2-0.0207x+0.6947$	0.9050
SK	**Polynomial 2nd degree**	$\mathbf{y= 0.0048x^2-0.1096x+1.1251}$	**0.7569**
	Polynomial 3rd degree	$y= 6E\text{-}06x^3 + 0.0046x^2-0.1077x+1.121$	0.7569
	Polynomial 4th degree	$y=-5E\text{-}05x^4+0.0023x^3-0.0291x^2+0.0739x+0.8708$	0.8277

Trends were estimated for every country where the coefficient of determination reached at least the value of 0.4 which means the likelihood of such future development of the indicator is at least 40%. To choose the appropriate and the most exact trend of development it is necessary to focus (beside the coefficient of determination (R^2) on the p-value and the result of the F test which were to have a value lower than 0.05 (Tab. 5, Tab. 6).

Table 5. Estimated parameters for regression models

Testing results	PL	SK
Correlation coefficient	0.94747	0.868361
Coefficient of determination	0.897699	0.75405
Adjusted coefficient of determination	0.886931	0.728161
Standard variable	0.048885	0.106106
Number of measurements	22	22
F test	3.92E-10	1.63E-06

Should the current development of the expenditure in Slovakia happen according to the power or logarithmic trend, the country would show a decrease of the monitored indicator and would gradually further itself from its target of 1.2% of GDP. On the contrary, should the actual development be guided by the polynomial function of the 2nd or 3rd degree, the country would already achieve its target value sometime during 2017 and 2018. Based on these results of testing the most appropriate function describing the indicator's development in Slovakia is the polynomial function of the 2nd degree. P-value for the constant 5.03E-12 < 0.05, for the regression coefficients 6.1E-07 < 0.05 and 3.4E-07 < 0.05,

which proves the statistical importance of the constant and the regression coefficients. The result of the F test 1.63E-06 < 0.05 proves the statistic importance of the estimated model. The likelihood the country will follow this trend in future years is 75.41%.

Table 6. Estimated parameters for regression models

		Coefficients	*Standard variable*	*P-value*	*Lower 95%*	*Upper 95%*
PL	Intercept	0.737532	0.034342	8.69E-15	0.665655	0.80941
	X Variable 1	-0.04106	0.006878	9.59E-06	-0.05545	-0.02666
	X Variable 2	0.002477	0.00029	6.37E-08	0.00187	0.003085
SK	Intercept	1.123831	0.074539	5.03E-12	0.967819	1.279844
	X Variable 1	-0.1093	0.01493	6.1E-07	-0.14055	-0.07805
	X Variable 2	0.004806	0.00063	3.4E-07	0.003487	0.006125

The several functions can be used for description of the actual trend of the indicator's development expressing the share of expenditure on R&D of GDP in Poland (Tab. 4). If the future development goes according to the linear or exponential function, by 2020 the country's indicator would stagnate approximately at the level of 0.9% of GDP. In case it would happen according to the polynomial function of the 4th degree the indicator would even drop to 0.72% of GDP.

Based on the results of testing the current and future expected development is described with the best accuracy by the polynomial function of the 2nd degree. In this case the p-value for the constant is 8.69E-15 < 0.05, for the regression coefficients are 9.59E-06 < 0.05 and 6.37E-08 < 0.05, which proves the statistic importance of the constant and also the regression coefficients. The result of the F test 3.92E-10 < 0.05 proves the statistic importance of the estimated model. The likelihood of the country experiencing this trend in future years is 89.77%.

Based on the stated results it is possible to determine the predicted values of the monitored indicator in the future and then evaluate whether that country will manage to achieve its set target by 2020 (Fig. 4, Tab. 7). If the current development of the share of expenditure on R&D of the GDP in Slovakia would be guided by the polynomial function of the 2nd degree, the country would reach its target of the Strategy between 2017 and 2018 with a likelihood of 75.41% and by 2020 the value of the indicator could increase up to 1.52% of GDP.

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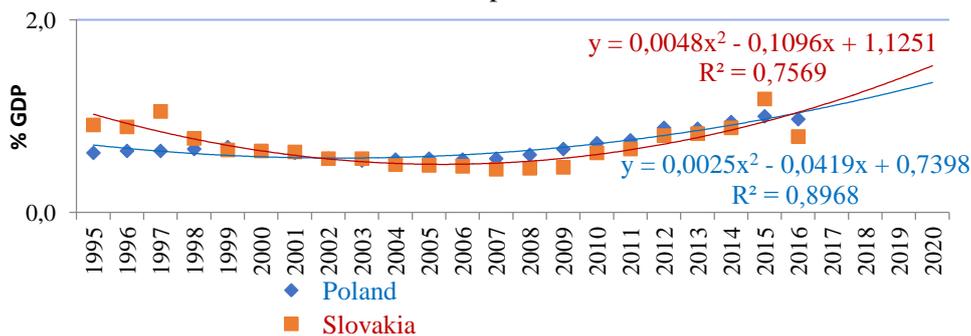
Figure 4. Expected development of the share of the expenditure on R&D of GDP by 2020

Table 7. Expected values of expenditure on R&D by 2020 (% of GDP)

	2017	2018	2019	2020	Target
Poland	1.10	1.17	1.25	1.34	1.70
Slovakia	1.14	1.26	1.39	1.52	1.20

Based on this statistically important model Poland should not attain the national target value set in the Strategy by 2020 but be slowly nearing them. If the development in Poland went according to the polynomial function of the 2nd degree, with almost a 90% likelihood the country would reach its target of 1.7% three years later, in 2024.

Majority of enterprises see as the main barriers to develop innovation activities bureaucracy and corruption and inappropriate state support of innovation activities. Specifically, Slovak enterprises suffer from a lack of financial sources to innovation, which significantly reduces their innovation activity; yet, the major obstacle lies in bureaucracy and corruption (Lesáková et al., 2017). Chybowska, Chybowski and Souchkov (2018) analysed the Polish R&D market and argue that dynamic changes occurring in Poland in recent years at governmental, social and economic levels, as well as the support provided by the EU will certainly allow Poland to close the gap with other developed economies. As regards socioeconomic local enablers of knowledge and innovation, GDP growth is positively influenced by the synergic effects deriving from agglomeration economies, by trust and social capital, and by informal knowledge embedded in technical and managerial competences (Capello and Lenzi, 2014).

The stimulation of R&D and innovation activities (Grimm, 2011; Ilbert and Petit, 2009) was declared to be the main measures employed to realise this strategic goal. In the literature there are no precise guidelines, indicators or methods that could be employed to evaluate the progress in implementing the Europe 2020 goals. The analyst is free to choose, largely unconstrained by economic or other theories intended to inform measurement practice. Authors Steurer and Hametner (2013) are dealing with these issues declare that people voluntarily or involuntarily, are always using indicators when they analyse, forecast and so on. Its importance is given by the fact that indicators are describing a topic of interest, reducing information overload for data users and provides the necessary information for decision-making.

Conclusion

Inadequate funding of R&D activities is a brake on innovation activity of enterprises. Nevertheless, managers should take into consideration that innovation is a prerequisite to get a competitive advantage in future (Lesáková et al., 2017). For the realization of R&D and innovation it is essential to have an established infrastructure in this area. For the reconstruction of research, development and

innovation infrastructure Slovakia began in the programming period 2007-2013 to use the financial resources from the Structural Funds under the Operational Programme Research and Development. In order to reduce disparities between Slovakia, Poland and other advanced countries of the EU, countries had the opportunity to utilize resources from the EU funds already in the pre-accession period. Financial resources from the EU fund in the current programming period may be the last for both countries which can be obtained.

Implementation of projects under the area research and innovation can bring many benefits. It is also necessary to focus on projects supporting innovative enterprises that have lack of own financial resources for R&D and innovation, thereby increase the level of their competitiveness. Poland increased public R&D expenditure with the aim to stimulate economic growth and again encourage private R&D investment (Szarowska, 2018). Improve the innovative potential and competitiveness of enterprises is also possible by improving collaboration and networking of domestic enterprises with the suppliers for large multinational companies, by strengthens cooperation of research centres with companies. The problem of the country is also the lack of participation of Slovak entities in the number of projects submitted in the call Horizon 2020, weak participation in international projects due to lack of experience of Slovak researchers participating in such projects.

Another option is to make study on the faculties of natural sciences and technical disciplines more attractive, to support the interest in job in research, to create jobs in science parks and create new enterprises using incubators in university science parks. To increase the competitiveness of Slovakia will positively impact also the support of creation new innovative spin-off and start-up businesses and penetration of domestic businesses into international markets. Instrument to support the realization of R&D is also called "Superodpočet", introduced by the Law 595/2003 from 1.1.2015. This allows businesses to deduct part of the expenditure related to R&D and innovation from the tax base (Law 595/2003, §30c).

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ZARZĄDZANIE DZIAŁALNOŚCIĄ BADAWCZO-ROZWOJOWĄ W KONTEKŚCIE STRATEGII EUROPA 2020

Streszczenie: Celem artykułu jest ocena aktualnej sytuacji zarządzania badaniami i rozwojem przez Polskę i Słowację, pod kątem realizacji strategii „Europa 2020" oraz w oparciu o wyniki analizy, prognozowanie oczekiwanego rozwoju wskaźnika do 2020 roku i ocenę celów krajowych w monitorowanym obszarze. Analiza regresji posłużyła do oszacowania charakterystyki trendów dla prognozowania oczekiwanego rozwoju wskaźnika wyrażającego udział wydatków na B + R w PKB do 2020r. Do opisu i oceny rozwoju monitorowanego wskaźnika w okresie 11 lub 22 lat wykorzystano porównanie trendów. Na podstawie otrzymanych wyników można określić przewidywane wartości wskaźnika w przyszłości, a następnie ocenić, czy krajowi uda się osiągnąć wyznaczony cel do 2020 roku.

Słowa kluczowe: zarządzanie, cel, strategia Europa 2020, badania, oczekiwany rozwój.

2020 年战略欧洲背景下的研究与开发活动管理

摘要：本文的目的是从波兰和斯洛伐克实现欧洲 2020 战略的角度评估研发管理的现状，并根据分析结果预测研究和发展管理的预期发展。到 2020 年的指标，并评估在监测区域达到其国家目标。回归分析用于估计趋势特征，用于预测指标的预期发展，该指标表示 2020 年国内生产总值研发支出的份额。为了描述和评估 11 年或 22 年期间监测指标的发展，我们正在使用趋势比较。根据所述结果，可以确定未来指标的预测值，然后评估该国是否能够在 2020 年之前实现其既定目标。
关键词：管理，目标，战略欧洲 2020，研究，预期发展。