National innovative performance and sustainable development

– the case of Slovakia

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Abstract. *Innovation are considered as the engine of sustainability and economic growth. Innovations are an integral part of the business that is expressed in scientific and research activities. If a company want to gain competitive advantage, it must do the business activities in accordance with economic, environmental, social and institutional factors. Business activities in this area are reflected in macroeconomic indicators of the country. This article deals with innovations and sustainable development issues. The main goal of research is testing interaction between innovations and sustainable development through the selected indicators. Summary Innovation Index (SII) represents innovations and sustainable development is represented by the set of indicators from four areas: economic, environmental, social and institutional. The analysis is based on values of the Summary Innovation Index proposed by the European Commission to measure the competitiveness of European countries in terms of innovation activity and values of sustainable development indicators such as GDP per capita, energy intensity of the economy, migration, transport performance, greenhouse gas emissions, application of environmental management system, mining and consumption of mineral resources, etc. The research is carried out on the case of Slovakia with application of mathematical-statistical apparatus (correlation analysis). The main benefit of research lies in the identification of strengths and weaknesses of Slovakia in analysed areas and determining the expected development.*

Keywords: *innovation, sustainable development, Summary Innovation Index*

Introduction

Economic competitiveness and growth are dependent nowadays on the several issues, such as environmental issues and business excellence involves taking full responsibility for a sustainable future (Nichifor et al., 2014). Global competitiveness has been one of the major goals of countries worldwide in the last few years, especially after the financial crisis emphasized the need for new strategies, innovations and dynamics in the economic and business environment (Dima et al., 2018).

Innovation and sustainable development have become the new buzzwords across the global world. Innovation are considered as the engine of sustainability and prerequisite for the sustainable growth.

Sustainable development principles are introduced into all sectors of the economy in order to ensure the economic, environmental and social sustainability of economic growth. These principles are becoming ones of the generally recognized principles of human society development. The main causes of its origin were global environmental problems such as climate changes, excessive consumption of certain population groups causing the plundering of natural resources and the rapid reduction of biodiversity.

The human development cannot be identified only with economic growth. It must go towards fulfilling important social goals such as reducing poverty, unemployment, improving the quality of life, ensuring access education, health care, etc. It requires a comprehensive approach to development based on managing interrelationships between natural and human, sectoral and structural aspects of development at all levels. Sustainable development is development that allows to meet the needs of today's generations without being endangered claims of future generations to fulfil their own needs.

Sustainable development issues represent an area of interest for scientific disciplines with a longer tradition, methodology, terminology etc. Sustainable development with its ethical, economic, political, technological, environmental, social and other implications represents a much wider, more heterogeneous phenomenon compared to individual scientific disciplines.

Sustainable development is considered as a prerequisite for economic growth, but on the other hand, a number of experts, authors of scientific research and politicians dealing with sustainable development draw attention to the individual pitfalls that bring about constant economic growth (Regnerova & Regnerova, 2017).

Innovation implemented in different areas of economic and social life have a significant impact on meeting sustainable development goals.

Literature review

Innovation and sustainable development issues have become very often discussed topics. The view that innovation is a key driver for sustainability is widely accepted among scholars, industry professionals, and government representatives. This is due to fact that sustainable development is a pressing issue that requires immediate action and changes from governments, industry, and society as whole (Silvestre & Tirca, 2019).

The literature converges to the fact that enhanced sustainability performance cannot be achieved without innovations (Silvestre, 2015). Research, innovation and sustainable education are important mechanism to achieve the Sustainable Development Goals (Salvia et al., 2019).

The industry experts emphasized that a collaborative and digitize education and the realization of more applied researches would already be a good starting point when attempting to seek innovations for sustainable development and thus implement SDGs (Caiado et al., 2018). Nagy et al. (2018) state in their research that substantial progress is awaited to be done by these localities in ensuring access to basic infrastructure, increasing investments in education, actions in attracting innovation, increasing social inclusion, and creating employment opportunities.

The increasing interest in these issues can be seen also based on the number of articles dealing with these issues indexed in Web of Science database (Valaskova et al., 2018; Ceniga & Sukalova, 2015; Gajanova, 2015; Krizanova et al., 2015 etc.). The total number of articles dealing with the sustainable development issue is 63530. An overview of number of articles in the years 1984 – 2018 is in the following figure.

Figure 1. Numbers of articles dealing with the sustainable development issues (WOS)

Source: Authors' own research.

The total number of articles dealing with the innovation issue is 211096. An overview of number of articles in the years 1984 – 2018 is in the following figure.

Figure 2. Numbers of articles dealing with innovation (WOS)

Source: Authors' own research.

The concepts of innovation and sustainable development are very closely related. Supporting innovation is one of the aim of the 2030 Agenda for Sustainable Development (Szopik-Depczynska et al., 2018a). Until recently, the sustainable development indicators published by Eurostat were divided into 10 thematic areas. Currently apart of this division, the new indicators system divided into 17 objectives of the Sustainable Development Strategy according The 2030 Agenda for Sustainable Development has been published (Szopik-Depczynska et al., 2018b).

The SDGs included in the 2030 Agenda for Sustainable Development aim to address the main challenges related to social, economic and environmental issues. Numerous single indicators have been established to monitor progress toward sustainable development (Diaz-Sarachaga et al., 2018). SDGs are a major focal point for international efforts to promote global welfare for the next decade (United Nations, 2015 in Fiorini & Hoekman, 2018).

The sustainable development goals (SDGs) are a set of 17 global goals (Tab. 1) adopted by all member states of the United Nations.

Table 1. Sustainable Development Goals

No. of goal	Name of goal	No. of goal	Name of goal
Goal 1	No poverty	Goal 10	Reducing inequalities
Goal 2	Zero hunger	Goal 11	Sustainable cities and communities
Goal 3	Good health and well-being for people	Goal 12	Responsible consumption and production
Goal 4	Quality education	Goal 13	Climate action
Goal 5	Gender equality	Goal 14	Life below water
Goal 6	Clean water and sanitation	Goal 15	Life on land
Goal 7	Affordable and clean energy	Goal 16	Peace, justice and strong institutions
Goal 8	Decent work and economic growth	Goal 17	Partnerships for the goal
Goal 9	Industry, innovation and infrastructure		

Source: 2030 Agenda for Sustainable Development.

The 17 Sustainable Development Goals clearly signal the path forward for coming years, as well as highlighting the need for stronger, more innovative public policies to ensure "that no young people will be left behind". The 2030 Agenda represents a unique opportunity for the State, private sector, civil society and the international cooperation system to harness positive synergies to improve young people's quality of life (Agosto et al., 2018).

There goals are at the centre of the global political agenda to eradicate extreme poverty, achieve universal education, promote gender equality and ensure environmental sustainability between other. There goals are organized in 169 indicators, which give an accurate perspective on the main dimensions related with country sustainable development (Guijarro & Poyatos, 2018).

Although the SDGs have a global approach, the actions taken are local and tend to depend on how far the countries are from achieving these goals. Besides that, the degree of development and commitment to sustainability of each country affects its internal interests and actions (Salvia et al., 2019).

There are several ways how to measure innovation activity of the counties. The most common is Summary Innovation Index (SII). SII is used for measure innovation performance of countries by many authors (e. t. Sipos et al., 2014; Sipos & Ionescu, 2015).

Following the positive impact of innovation, the European Commission outlined the most common strategies for the European Union countries to promote innovative activities at European level to achieve the level of the performance recorded in this area by the United States and Japan. Hence, an aggregate indicator of innovation, the SII, was created to allow measuring of the level of the innovation performance and adopting of some effective strategies for the purposes of intensifying its influence on the macroeconomic level (Stoian & Nica, 2016; Bavec, 2009).

Methodology

On basis of literature and in our opinion, we hypothesize relationship between innovation and sustainable development.

The analysis is based on values of the Summary Innovation Index proposed by the European Commission to measure the competitiveness of European countries in terms of innovation activity and values of sustainable development indicators represented by the set of indicators (integral part of the Agenda 2030). Agenda 2030 contains 169 goals divided into 17 main global goals, but not all of the data are available for Slovak Republic for the period of our research (2010 – 2017). Due to this fact (unavailability of some data), we had to reduce the sample of indicators from 169 to 61 (Tab. 2). Some of indicators are duplicate, because they are related to the more than one goal.

Table 2. Selected Indicators of Sustainable Development

Goal	No.	Indicators
1	1.1	People at risk of poverty or social exclusion
	1.2	People at risk of income poverty after social transfers
	1.3	Severely materially deprived people
	1.4	People living in households with very low work intensity
	1.5	In-work at-risk-of-poverty rate
	1.6	Population living in a dwelling with a leaking roof, damp walls, floors or foundation or rot in window frames of floor by poverty status
	1.7	Self-reported unmet need for medical examination and care by sex
	1.8	Population having neither a bath, nor a shower, nor indoor flushing toilet in their household
	1.9	Population unable to keep home adequately warm by poverty status
	1.10	Overcrowding rate by poverty status
2	2.1	Government support to agricultural research and development
3	3.1	Share of people with good or very good perceived health
	3.2	Self-reported unmet need for medical examination
	3.3	Population living in households considering that they suffer from noise
4	4.1	Early leavers from education and training
	4.2	Tertiary education attainment
	4.3	Employment rates of recent graduates
	4.4	Adult participation in learning
	4.5	Young people neither in employment nor in education and training
5	5.1	Gender employment gap
	5.2	Inactive population due to caring responsibilities
	5.3	Seats held by women in national parliaments and governments
	5.4	Positions held by women in senior management positions
	5.5	Early leavers from education and training
	5.6	Tertiary educational attainment
	5.7	Employment rates of recent graduates
6	6.1	Population having neither a bath, nor a shower, nor indoor flushing toilet in their household
7	7.1	Population unable to keep home adequately warm
8	8.1	Real GDP per capita
	8.2	Investment share of GDP by institutional sectors
	8.3	Young people neither in employment nor in education and training
	8.4	Employment rate
	8.5	Long-term unemployment rate
	8.6	In work at-risk-of-poverty rate
	8.7	Inactive population due to caring responsibilities
	8.8	Resource productivity and domestic material consumption
9	9.1	Gross domestic expenditure on R&D by sector

	9.2	Employment in high-and medium-high technology manufacturing sectors and knowledge-intensive service sectors
	9.3	R&D personnel by sector
	9.4	Patent applications to the European Patent Office
10	10.1	Purchasing power adjusted GDP per capita
	10.2	Adjusted gross disposable income of households per capita
	10.3	Relative median at-risk-of-poverty gap
	10.4	Income distribution
	10.5	Income share of the bottom 40 % of the population
	10.6	Asylum applications by state of procedure
	10.7	People at risk of income poverty after social transfers
	10.8	EU imports from developing countries by country income groups
11	11.1	Overcrowding rate by poverty status
	11.2	Population living in households considering that they suffer from noise
	11.3	Population living in a dwelling with a leaking roof, damp walls, floors or foundation or rot in window frames of floor by poverty status
	11.4	Population reporting occurrence of crime, violence of vandalism in their area
12	12.1	Resource productivity and domestic material consumption
	12.2	Average CO2 emission per km from new passenger cars
13	13.1	Average CO2 emissions per km from new passenger cars
14	-	-
15	-	-
16	16.1	Population reporting occurrence of crime, violence of vandalism in their area
	16.2	Population with confidence in EU institutions by institution
17	17.1	Official development assistance as share of gross national income
	17.2	EU imports from developing countries by country income groups
	17.3	General government gross debt
	17.4	Shares of environmental and labor taxes in total tax revenues

Source: 2030 Agenda for Sustainable Development.

There are differences in the emphasis to the implementation of the SDGs across different geographical regions (Salvia et al., 2019), therefore the secondary goal of this research is comparison results of Slovak Republic with the European Union average.

The **Pearson's correlation coefficient** is applied to find out whether there is a linear relationship between the SII and selected indicators of sustainable development for the reporting period 2010-2017. When interpreting the calculations of correlation coefficients, we draw on the following guidelines (Tab. 3).

Table 3. Degree of Correlation

Correlation Coefficient	Degree of Correlation
0.0 – 0.3 (+/-)	low (positive/negative)
0.3 – 0.7 (+/-)	medium (positive/negative)
0.7 – 1.0 (+/-)	high (positive/negative)

Source: Authors' own research.

Results and discussions

The research results present relationship between the innovation represented by the Summary Innovation Index and the selected indicators of sustainable development. The aim was to prove, among which indicators of sustainable development and SII is the highest positive or negative linear correlation in the case of Slovak republic and to compare with European Union average. Summary results are shown in the following table (Tab. 4).

Table 4. Correlation between SII and SD indicators – Pearson's correlation coefficient

		Indicators of Sustainable Development										
	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	2.1	
SR	0.500	0.318	0.592	0.632	-0.319	0.301	-0.236	-0.374	0.656	0.433	0.329	
EU	0.555	-0.873	0.654	0.066	-0.879	0.414	0.445	0.831	0.567	0.671	0.214	
	3.1	3.2	3.3	4.1	4.2	4.3	4.4	4.5	5.1	5.2	5.3	
SR	-0.526	-0.236	0.196	-0.592	-0.595	-0.590	0.016	0.509	0.831	-0.705	-0.278	
EU	0.218	0.445	0.791	0.863	-0.842	-0.441	-0.780	0.686	0.757	-0.777	-0.833	
	5.4	5.5	5.6	5.7	6.1	7.1	8.1	8.2	8.3	8.4	8.5	
SR	-0.067	-0.592	-0.595	-0.590	-0.374	0.656	-0.465	0.196	0.509	-0.625	0.655	
EU	-0.873	0.863	-0.858	-0.440	0.831	0.567	-0.780	-0.119	0.686	-0.759	0.113	
	8.6	8.7	8.8	9.1	9.2	9.3	9.4	10.1	10.2	10.3	10.4	
SR	-0.319	-0.705	-0.240	0.109	-0.419	-0.492	-0.382	-0.357	-0.359	0.085	0.542	
EU	-0.879	-0.777	-0.759	-0.746	-0.868	-0.833	0.519	-0.879	-0.891	-0.885	-0.918	
	10.5	10.6	10.7	10.8	11.1	11.2	11.3	11.4	12.1	12.2	13.1	
SR	-0.680	0.406	0.318	-0.543	0.433	0.196	0.301	0.519	-0.240	0.260	0.260	
EU	0.684	-0.839	-0.873	-0.598	0.671	0.791	0.414	0.573	-0.759	0.862	0.862	
	16.1	16.2	17.1	17.2	17.3	17.4						
SR	0.518	0.010	-0.676	-0.543	0.080	0.324						
EU	0.573	0.274	-0.605	-0.598	-0.341	0.573						

Source: Authors' own research.

In case of Slovakia, only 3 indicators of sustainable development are strong correlated to the SII. The indicator with strong positive correlation is *Gender employment gap* ($r = 0.831$) and indicators with strong negative correlation are 5.2 and 8.7. It is duplicate indicator *Inactive population due to caring responsibilities* ($r = 0.831$). In case of EU countries, 32 indicator are strong correlated to the SII (23 negative, 9 positive).

There are many differences in results of Slovakia and EU countries, but on the other hand, we can see also some similarities (e. g. in these 17 indicators: 1.1, 1.3, 1.6, 1.9, 1.10, 4.5, 5.1, 5.2, 5.7, 7.1, 8.3, 8.7, 11.1, 11.3, 11.4, 16.1, and 17.4). It means that the development of these 17 indicators in relation to the SII in Slovakia is comparable to the average of the EU countries. An overview of the number of low, medium, and high correlation between SII and SD indicators is shown in the tab. 5.

Table 5. Overview of Correlation between SII and SD indicators

	Positive correlation			Negative correlation		
	low	medium	high	low	medium	high
SR	10	20	1	6	22	2
EU	5	17	9	1	6	23

Source: Authors' own research.

Not even a value of correlation coefficient does automatically imply a causal relationship between variables. The ***coefficient of determination***, denoted r^2 is the proportion of the variance in the dependent variable that is predictable from the independent variable. Summary results are shown in the table 6.

Table 6. Coefficient of determination (SII vs. SD indicators)

Indicators of Sustainable Development										
1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	2.1

SR	0.250	0.101	0.350	0.399	0.102	0.090	0.056	0.140	0.431	0.188	0.108
EU	0.308	0.763	0.428	0.004	0.772	0.171	0.198	0.690	0.321	0.451	0.046
	3.1	3.2	3.3	4.1	4.2	4.3	4.4	4.5	5.1	5.2	5.3
SR	0.276	0.056	0.038	0.351	0.354	0.348	0.000	0.259	0.691	0.498	0.078
EU	0.048	0.198	0.626	0.744	0.710	0.194	0.608	0.470	0.573	0.604	0.694
	5.4	5.5	5.6	5.7	6.1	7.1	8.1	8.2	8.3	8.4	8.5
SR	0.004	0.351	0.354	0.348	0.139	0.431	0.216	0.038	0.259	0.391	0.429
EU	0.763	0.744	0.736	0.194	0.690	0.321	0.609	0.014	0.470	0.577	0.013
	8.6	8.7	8.8	9.1	9.2	9.3	9.4	10.1	10.2	10.3	10.4
SR	0.102	0.498	0.058	0.011	0.176	0.242	0.146	0.127	0.129	0.007	0.294
EU	0.772	0.604	0.576	0.557	0.753	0.693	0.270	0.772	0.792	0.784	0.843
	10.5	10.6	10.7	10.8	11.1	11.2	11.3	11.4	12.1	12.2	13.1
SR	0.463	0.165	0.101	0.295	0.188	0.038	0.090	0.268	0.058	0.067	0.067
EU	0.468	0.705	0.763	0.358	0.451	0.626	0.171	0.328	0.576	0.743	0.743
	16.1	16.2	17.1	17.2	17.3	17.4					
SR	0.268	0.000	0.457	0.295	0.006	0.105					
EU	0.328	0.075	0.366	0.358	0.116	0.329					

Source: Authors' own research.

In case of Slovakia, coefficients of determination are relatively low. The highest value of this coefficient is 0.691 in case of 5.1 SD indicator (*Gender employment gap*). It means that 69.1 % changes in this variable are caused by changes in the second variable (SII). In case of EU countries (average), the highest values of the r^2 coefficient is 0.843. It means that 84.3 % changes in one variable (*10.4 – Income distribution*) are caused by changes in the second variable (SII).

Conclusion

Innovations are a prerequisite for meeting sustainable development goals and it is very important to monitor their interdependence. An analytical approach to monitoring the relationship between innovation activity of countries and selected indicators of sustainable development is an appropriate way to monitor efficiency of innovation. Based on this approach, authors identified that innovation activity of the Slovak Republic strongly correlates with the two indicators of sustainable development.

The innovation activity of the Slovak Republic significantly influences the difference between the employment rate of men and woman. If innovation activity increases, the gender employment rate also increases. This situation can be considered a negative phenomenon, or negative consequence of innovation. This situation may be caused by the fact that innovations are predominantly technical in nature and the male employment rate is higher in these technical sectors. It is necessary to place greater emphasis on equal opportunity for men and women.

On the other hand, if innovation activity increases, the number of inactive people due to caring responsibilities decreases. This phenomenon can be caused by several factors, e.g. demographic changes, an ageing population, etc. However, it can be also caused by innovation, because many innovative companies allow to work to people with caring responsibilities (e. g. part time job, home office job, etc.).

The authors are aware that the period for which the correlation analysis was realized is not long enough to formulate definitive conclusions. On the one hand, the limitation is given by the reporting methodology of the Summary Innovation Index, and on the other hand by the availability of Sustainable Development Indicators values. This research is oriented to the

long-term monitoring of the relationship between these variables. Despite these limitations, we can state at the level of current results of the analysis that innovation and sustainable development go hand in hand. These mutually supportive variables have a significant impact on the economic growth. It is proven that countries with a high value of Summary Innovation Index have a high sustainable development rate.

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