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Eco-innovation Performance in Slovakia: Assessment Based on ABC Analysis of Eco-innovation Indicators

Erika Loučanová,* and Martina Nosáľová

The development of the global economy is accompanied by growing environmental pollution, which has led to a change in attitudes and a need to promote sustainability. Modern innovation policy is becoming increasingly environmentally oriented. The purpose of this paper was to estimate the current situation of eco-innovation's development in Slovakia. Eco-innovation Index analysis results showed that, in general, Slovakia is in the group of countries that are moderate innovators, with an innovation performance below the European Union average. Eco-innovation generally positively influences the environmental, economic, and social growth of companies that gradually adopt sustainable development. Therefore, it is convenient to identify the eco-innovative performance of Slovakia as well as to analyze the critical issues, which may also influence the desired positive development of eco-innovation in the future.

*Contact information: Department of Marketing, Trade and World Forestry, Technical University in Zvolen, T. G. Masaryka 24, 960 53 Zvolen, Slovakia; *Corresponding author: loucanova@tuzvo.sk*

INTRODUCTION

The scale of environmental problems, as well as global economic competition, has raised increasing awareness for the need to change and renew existing technological production and social behavioral patterns. Such awareness may gradually produce innovative responses leading to sustainability (Könnölä *et al.* 2008; Carrillo-Hermosilla *et al.* 2009).

According to the Oslo Manual (2005), innovation is the implementation of a new or significantly improved product or process, a new marketing method, or a new organizational method in business practice. The general definition of innovation is neutral regarding the content of change; the definition is open in all directions. In contrast, putting emphasis on innovation toward sustainable development is motivated by concern about the direction and content of the progress (Klemmer *et al.* 1999). Environmental innovation (eco-innovation) can be defined broadly as all measures by relevant actors (companies, politicians, unions, associations, churches, private households) that: 1.) develop new ideas, behavior, products, and processes; 2.) apply or introduce them; and 3.) contribute to a reduction of environmental burdens or to ecologically specified sustainability targets (Rennings 2000). Based on the Measuring eco-innovation (MEI) European Commission project (Kemp and Pearson 2007), eco-innovation is the production, assimilation, or exploitation of a product, production process, service, or management or business method that is novel to the organization (developing or adopting it), and that results, throughout its life cycle, in a reduction of environmental risk, pollution, and other negative impacts of resource use compared with relevant alternatives.

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Regarding the approach of eco-innovation, authors have claimed that the more innovative a company is, the more environmentally friendly it will be (Bucar *et al.* 2003; Dangelico and Pujari 2010; Triguero *et al.* 2013; Lee and Min 2015). Thus, effective management of both innovation and environmental issues suggests that companies with higher-quality innovation will take better care of the environment. Eiadat *et al*. (2008) and, subsequently, Zhen (2011) identified the equality and mutual benefit that proceed from the relationship between eco-innovation and a business's performance. According to Lešková (2009), eco-innovation decreases material demands by using closed material flows or by creating or using new materials. At the same time, ecological innovations are focused on decreasing energy demands or creating/using alternative sources of energy. They also decrease the total amount of emissions or existing environmental load and health risks while supporting healthy lifestyles and sustainable consumption.

Ryszko (2016) reported that companies can, through technological eco-innovation, not only improve their corporate image and achieve better customer satisfaction, but can also generate an increase in market share, profit growth, return on sales, *etc*. Because technological eco-innovation reduces environmental impact and improves business performance, it simultaneously contributes to environmental and economic pillars of sustainable development.

The forest-based bioeconomy and EU's Bioeconomy Strategy state that forests and related industries (wood industry *etc*.) have always been an important part of the bioeconomy. As a manifestation of this strategy, building houses from wood would save two tonnes of CO_2 for each tonne of cement used (Intergoup 2020). The changing market environment and a non-functional innovation system in Slovakia (Štěrbová *et al.* 2018) forces the traditional forestry industry to adapt, and the analysed European cases indicate that business system innovations should always be considered to meet consumers' needs. The business models introduce new organizational channels for reaching customers, satisfying new customer needs, targeting unique customers, reducing transaction costs, and improving customer relationships (Štěrbová *et al.* 2016; Šoltés and Štofková 2016; Kajanus *et al.* 2019; Loučanová and Olšiaková 2020). For the purpose of innovations development, Rametsteiner and Weiss (2006) propose a more complex system view of innovation "as a complex non-linear process involving a range of players and different interactions", with the focus on the social elements of the system. New wood-based plastics and textile products with lower environmental footprint are also emerging within the bioeconomy. Even though there are limitations on how much biomass can be produced, there is still unlocked potential and further innovations to be discovered (Intergoup 2020; Kalamárová *et al*. 2014).

Furthermore, Picazo-Tadeo *et al.* (2014) and Färe *et al.* (1994) stated that a change in environmental performance is part of proportionate eco-efficiency change and also environmental technical change. Eco-innovation can serve as a tool by which companies attempt to transform environmental constraints into opportunities to reduce costs, to obtain a better reputation, and to take advantage of new markets. One of the most important consumer interests is the promotion of environmental product innovation and performance. (Carrillo-Hermosilla and Unruh 2006; Laperche and Picard 2013; Loucanova *et al.* 2015).

This paper is largely based on the approach of the European Commission (European Commission 2011). The Eco-Innovation Index, a composite index indicator, allows measuring the eco-innovation performance of different EU member states. The ranking of EU member states is dependent on their deviation from the EU average. In 2017, the highest rated EU country was Sweden as the leader in this field, followed by Finland,

Germany, Luxembourg, Denmark, Slovenia, Austria, Italy, Spain, Portugal, and the United Kingdom, which all obtained higher ratings than the EU average.

The Eco-Innovation Index of Slovakia in 2017, compared with other EU countries was below the EU average. Slovakia was among the ten member states with the lowest ranking in this field. The obtained score of 74 ranked Slovakia in 21st place of 28 EU countries. Slovakia was in the group of moderate innovators countries with an innovation performance below the EU average.

In the case of the Eco-Innovation Index, a high overall ranking does not necessarily mean that a country has performed well in all eco-innovation areas covered by this index. The results of the index can only provide an indication of the overall country performance of eco-innovation. Rizos *et al.* (2015) emphasized that drawing conclusions about specific eco-innovation aspects and country trends requires a careful analysis of the sub-indicators covering these fields, for that the aim this article is analyze the current situation of eco-innovation's development in Slovakia.

EXPERIMENTAL

This paper evaluated Slovakia's eco-innovation situation, which is defined according to the Eco-Innovation Index and its five thematic areas. Using ABC analysis, the aim is to identify the most important areas influencing eco-innovation development in Slovakia. According to the European Commission, the Eco-Innovation Index (European Commission 2011) shows how well individual member states perform in different dimensions of eco-innovation compared with the European Union (EU) average, and presents their strengths and weaknesses. The intention of the Index is to acquire various aspects of eco-innovation by applying 16 different indicators that are grouped into five thematic areas: eco-innovation inputs, eco-innovation activities, eco-innovation outputs, resource efficiency, and socio-economic outcomes (Table 1).

According to the European Commission (2011), every area is measured according to a score. The Eco-Innovation Index is counted individually for each country, where specific figures of a single indicator are weighted with the share of the population. The "distance-to-reference" method is used to normalize different indicators. The EU average is defined as the reference, and a set is defined as a value of 100. Countries whose figures are higher than the EU average obtain a higher score than 100, and countries whose figures are lower receive a score lower than 100. The specific value is dependent on the deviation from the EU average.

The value to index consists of 16 indicators from 8 different data sources. Thus the EU average of a sub-indicator displays the weighted mean of all country specific data of the EU Member States. The value of the sub-index in each of the five areas is calculated by the unweighted mean of the values to underlying indicators. Consequently, each indicator has the same weighting in the five areas. The overall index value of each EU Member State is calculated by the unweighted mean of the 16 indicators in order to avoid a bias between the thematic areas of the index (European Commission 2011).

First, to evaluate the current situation in the area of eco-innovation in Slovakia, the authors of the present study analyzed the Eco-Innovation Index data for the year 2017 and the causalities in its developments in the years 2010 to 2017.

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Table 1. Thematic Areas of Innovation Index

Eco-innovation Inputs	Eco-innovation Activities	Eco-innovation Outputs	Resource Efficiency Outcomes	Socio-economic Outcomes
Governments' environmental and energy research and development appropriations and outlays	Enterprises that introduced an innovation with environmental benefits obtained within the enterprise	Eco-innovation-related patents	Material productivity	Exports of products from eco-industries
Total research and development personnel and researchers	Enterprises that introduced an innovation with environmental benefits obtained by the end user	Eco-innovation related academic publications	Water productivity	Employment in eco-industries
			Greenhouse gas emissions intensity	
Total value of green early stage investments	ISO 14001 (2015)-registered organizations	Eco-innovation related media coverage	Energy productivity	Turnover in eco-industries

Source: Authors according to Eco-Innovation Index, European Commission (European Commission 2011)

As the second step, the ABC analysis of the individual areas' influence on the value of Eco-Innovation Index in Slovakia was calculated based on the European Commission's eco-innovation data (European Commission 2011). The ABC analysis can use different criteria to group "items," resulting in various groupings. The use of ABC analysis to rank items depends on the goals a company's management needs to accomplish (Coyle 2009). According to Li *et al.* (2018), ABC analysis is a popular and effective method used to classify items into specific categories that can be managed and controlled separately. The three predefined and ordered categories are:

1. Category A, which contains the very important items (approximately 70 to 80% share of the total value of the parameter, and approximately 10 to 15% share of the total number of elements);
2. Category B, which includes the moderately important items (approximately 15 to 20% share of the total value of the parameter, and approximately 15 to 20% share of the total number of elements);
3. Category C, which contains the relatively unimportant items (approximately 5 to 10% of the total value of the parameter, and about 60 to 80% of the total number of elements).

This classification is based on the Pareto principle and the analysis of a range of items that have different levels of importance, and thus should be handled or controlled differently. Graphic presentation of the ABC analysis results is completed using the Lorenz curve, an indicator that reflects the concentration of the studied phenomenon. The curve plots the cumulative expression of the individual variables ("Lorenz Curve").

In inventory management, ABC analysis is the most widely used technique (Ng 2007; Douissa and Jabeur 2016). According to Chen *et al.* (2008), a recent trend is to develop various procedures to conduct ABC analysis in terms of multiple criteria. In the present study, ABC analysis provided information on how the individual thematic areas contributed to the absolute value of Slovakia's Eco-Innovation Index. It provided a

mechanism for identifying areas that could have a remarkable impact on the overall eco-innovation situation in Slovakia. The identified areas are important for deciding whether to support or eliminate these thematic areas within the strategy in Slovakia.

All thematic areas of the Eco-Innovation Index were chosen as the evaluation object, and they were listed in descending order according to their contribution to Slovakia's Eco-Innovation Index. Subsequently, percentage shares of individual thematic areas were calculated, and, according to the calculation of the accumulated value (%), the results were presented graphically using the Lorenz curve.

RESULTS AND DISCUSSION

The Eco-Innovation Index also aims to assess how eco-innovation is unfolding in several relevant areas such as research and development (R&D) investments, the performance of firms, and socio-economic and environmental outcomes. The Index includes 16 different indicators that are classified into five thematic categories: eco-innovation inputs, eco-innovation activities, eco-innovation outputs, resource efficiency outcomes, and socio-economic outcomes.

For more in-depth analysis, the present study identified the value of all 16 individual indicators of the Eco-Innovation Index thematic areas of Slovakia, per the eco-innovation data of European Commission. Their percentages were calculated, as well as the cumulative values that classify these indicators into Group A, B, or C according to their importance for eco-innovation in Slovakia (Table 2).

Table 2. Data for ABC Analysis Eco-Innovation Index Indicators of Slovakia in 2017 According to the Eco-Innovation Database

Indicators of Eco-Innovation Index of Slovakia	Value	% of Total	Cumulative %
Water Productivity	252	18.42	18.42
ISO 14001 (2015)–registered Organizations	252	18.42	36.84
Turnover in Eco-industries	227	16.59	53.43
Employment in Eco-industries	117	8.55	61.99
GHG Emissions Intensity	75	5.48	67.47
Material Productivity	70	5.12	72.59
Energy Productivity	62	4.53	77.12
Exports of Products from Eco-industries	52	3.80	80.92
Eco-innovation–related Academic Publications	48	3.51	84.43
Eco-innovation–related Media Coverage	45	3.29	87.72
Enterprises that Introduced an Innovation with Environmental Benefits Obtained within the Enterprise	43	3.14	90.86
Enterprises that Introduced an Innovation with Environmental Benefits Obtained by the End User	43	3.14	94.00
Total R&D Personnel and Researchers	38	2.78	96.78
Governmental Environmental and Energy R&D Appropriations and Outlays	32	2.34	99.12
Eco-innovation–related Patents	11	0.80	99.93
Total Value of Green Early Stage Investments	1	0.07	100.00

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The impact of the Eco-Innovation Index individual indicators in Slovakia is illustrated in Fig. 1. Items in Category A are the most important and contribute quite heavily to Slovakia's eco-innovation index. They include water productivity, ISO 14001 (2015)–registered organizations, and turnover in eco-industries. Category B items represent moderately important items with much potential to improve, and include employment in eco-industries, the level of GHG emissions, and material productivity. The remaining items fall within Group C, which has the highest number of indicators but the lowest share of the total Eco-Innovation Index effect.
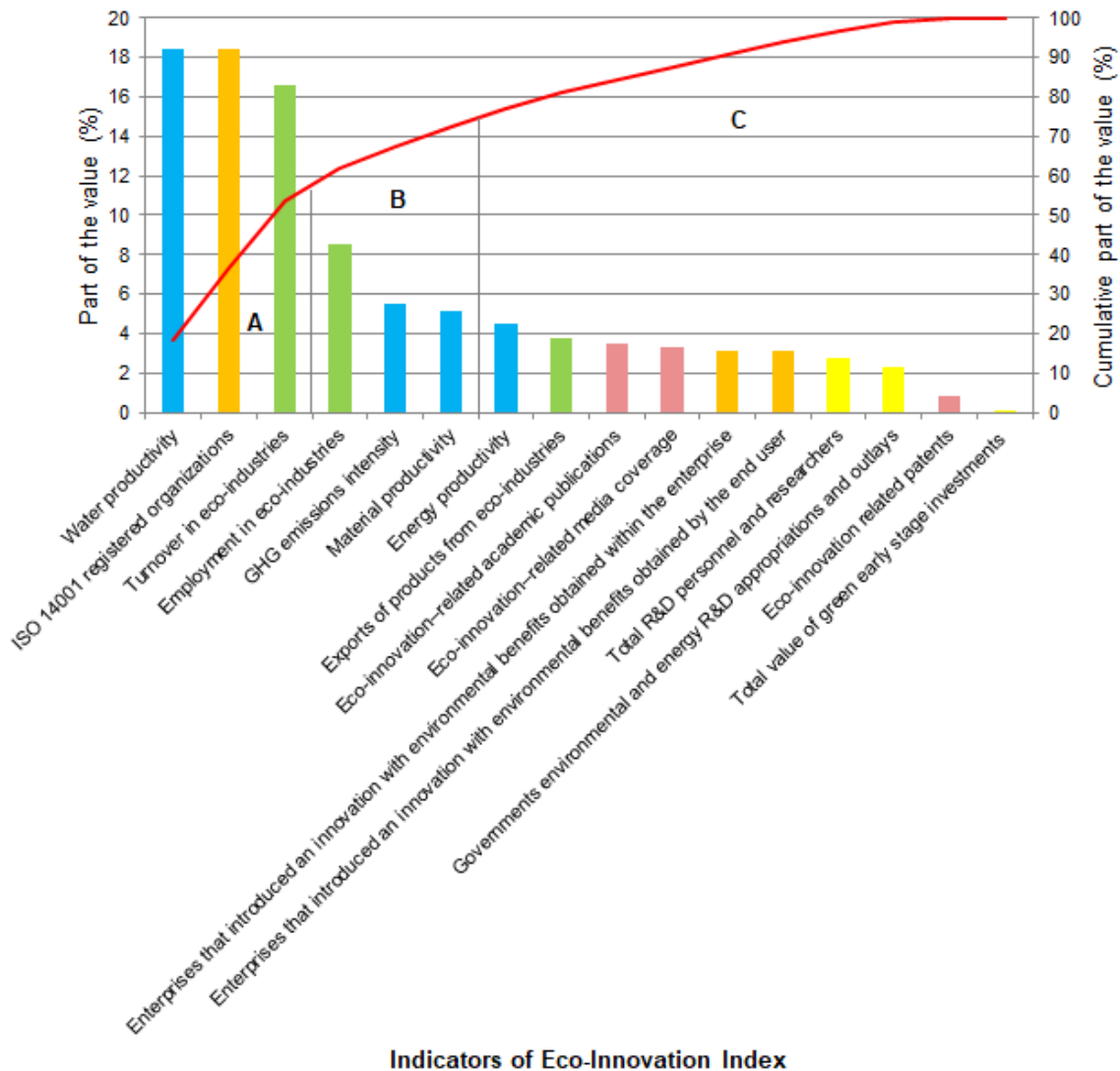

Indicators of Eco-Innovation Index

Fig. 1. ABC analysis of Eco-Innovation Index indicators of Slovakia in 2017 according to the Eco-Innovation Database

The Eco-Innovation Index is positively influenced mainly by the activities carried out in the mentioned areas (socio-economic outcomes, eco-innovation activities, and resource efficiency outcomes), namely activities of water productivity, ISO 14001 (2015)–registered organizations, turnover in eco-industries, the level of Greenhouse gas (GHG) emissions, employment in eco-industries, and material productivity according to ABC

analysis (Categories A and B). The other conducted activities did not influence to a significant extent the positive development of eco-innovation in Slovakia as greatly (Category C). The value of green early stage investment had the least impact on the eco-innovation index, because forestry is often considered as a "Low-tech" declining industry (Rametsteiner and Weiss 2006), which invests relatively little into research, development and innovation (Loučanová *et al.* 2017).

Eco-innovation in Slovakia has an increasing tendency (Fig. 2), when observing development in the years 2010 to 2017. It is worth noticing that 2013 was heavily influenced by indicators in the area of socio-economic outcomes, and the value reached a low of 42. The current situation is different and socio-economic outcome indicators report the highest values, affecting the overall Eco-Innovation Index.

The Eco-Innovation Index in Slovakia has generally increased over time, except for slight decreases in 2013 and 2017. The monitored areas of resource efficiency outcomes, socio-economic outcomes, and eco-innovation activities all demonstrated an upward trend; however, the areas of eco-innovation inputs and outputs demonstrated slightly descending trend in 2017. That decrease, according to ABC analysis, was noticeably caused by negative development, mainly in the total value of green early stage investments, eco-innovation-related patents, governmental environmental and energy R&D appropriations and outlays, and total R&D personnel and researchers. The area of eco-innovation outputs stagnated.
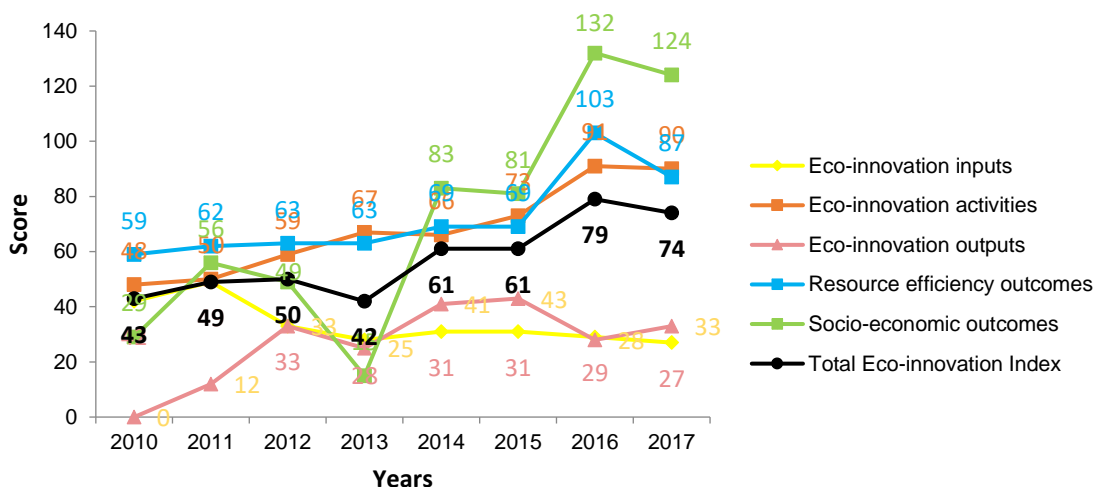

Fig. 2. Development of Eco-Innovation Index thematic areas in Slovakia in 2017, according to the Eco-Innovation Database (European Commission 2011)

In order to reverse negative development of the eco-innovation index in the last year and for its further growth, it is convenient to support eco-industry product exports, material and energy productivity, research and development in the area of the environment, energy research within the open system of innovations, and also research in other areas connected to Slovakia's environmental policy.

On the basis of the above findings, promoting eco-innovation in Slovakia has a growing tendency. Therefore, eco-innovation in Slovakia should continue to be implemented. Continued support for eco-innovation in Slovakia would encourage a positive growth rate of the Eco-innovation Index as it approaches the EU average.

In Slovakia, eco-innovation is supported in particular by the National Strategy for Sustainable Development approaches (Úrad Vlády SR 2001). The strategy is directly linked to the major priorities of the EU, the United Nations, and the Organization for Economic Cooperation and Development, which support eco-innovation and sustainable development. This strategy deals with economic growth focused on the long-term needs of society and the respect of environmental approaches. It takes into account the criteria for maintaining and supporting biodiversity, vitality, and the resilience of ecosystems; optimizing the spatial arrangement and functional use of the landscape and ensuring its territorial system of ecological stability; maintaining and supporting life-assurance systems; maintaining a high quality of the environment; and minimizing the use of limited resources.

However, there is still space for improvement, as the overall Eco-Innovation Index of Slovakia is below average within the standards of the EU. To improve the situation, it is convenient to focus mainly on supporting the exports of products from eco-industries, environmental research and development, energy research within the open system of innovations, and research in other areas connected to Slovakia's environmental policy. These areas have lower values as monitored indicators within the Eco-Innovation Index. According to a study by Jeck (2012), environmental regulation and pollution taxes are the most important factors in introducing eco-innovation to Slovak companies. An important factor related to eco-innovation is also the effort to reduce material and energy costs. Compared with companies in other EU countries, Slovak companies are less affected by customer demand, by the financial incentives offered by the public sector, and by the adoption of voluntary codes and agreements within the industry.

The most remarkable barriers to eco-innovation in Slovak companies are financial factors and factors related to uncertain development (market or investment). Attempting to reduce energy and material demand, Slovak companies recycle, outsource production activities, and purchase finished technology. Preferring to purchase ready-made technology rather than developing it themselves is characteristic of Slovak companies' eco-innovation behavior. As mentioned by Hrabynskyi *et al.* (2017), all EU members generally face the same barriers to eco-innovation, and policy-makers are obliged to address existing restrictions to correct and implement effective methods and instruments of eco-innovation policy. Additionally, according to the Eco-Innovation Observatory (EIO) Country Profile (European Commission 2011), the regulatory and policy framework for innovation is highly fragmented and insufficient in its promotion of environmentally friendly behavior in Slovakia. The lack of market demand for innovation and the low level of public awareness on this topic are also barriers.

The contribution of this paper's findings points not merely to the current status of Slovakia in terms of eco-innovation, but also to a way to identify weaknesses and opportunities for eco-innovation improvements leading to environmental and economic pillars of sustainable development. That is the very essence of eco-innovation, as, according to Mavi and Standing (2017), companies eco-innovate to promote eco-efficiency and sustainability and for environmental friendliness. Eco-innovation can serve as a tool by which companies attempt to transform environmental constraints into opportunities that can reduce costs, earn them a better reputation, and give them the advantage of new markets. One of the most important interests to a country's policies is to promote the performance and implementation of environmental product innovations (Färe *et al.* 1994; Carrillo-Hermosilla *et al.* 2009; Parobek *et al.* 2014; Picazo-Tadeo *et al.* 2014).

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CONCLUSIONS

1. Slovakia has a low level of eco-innovative efficiency.

2. Slovakia has a score below the average of the European Union's 28 countries and needs a more effective supporting program.

3. Eco-Innovation in Slovakia is positively influenced mainly by the activities of water productivity, ISO 14001 (2015); registered organizations; and turnover in eco-industries (approximately 53.4% share of the total value of the Eco-Innovation Index)

4. Slovakia's negative development in the last few years has been mostly in the area of eco-innovation inputs and outputs.

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