






“Does standardization have an impact on innovation activity in different countries?”

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DOES STANDARDIZATION HAVE AN IMPACT ON INNOVATION ACTIVITY IN DIFFERENT COUNTRIES?

Abstract

Nowadays, innovation and standardization are very important issues. The aim of this paper was to review the relationship between the components of the Summary Innovation Index (SII) according to the European Innovation Scoreboard and the features that determine the innovation level in 35 countries (taking into account the number of the following certificates: ISO 9001, ISO 14001, ISO 27001, ISO 50001, ISO 22000, ISO 13485) in 2017. The innovation ranking was created for these countries, considering the fact of certification for compliance with the ISO requirements. In this paper, an attempt was made to determine whether countries with very low innovation activity (performance) are at the same time characterized by a very low level of saturation with globally recognized ISO certificates, which confirm the implementation, functioning and improvement of selected types of management systems. The conclusions from the study are as follows: 1) standardization can be seen as an innovation tool; 2) as the number of ISO 9001 certificates increases, the number of ISO 14001 certificates (per the population of 100,000 people) also increases; 3) as the number of ISO 13485 certificates increases, the value of the SII also becomes higher. The features are modelled at 70%; 4) the weakest relationship can be observed between the SII and the ISO 9001 certification; 5) Switzerland obtained the highest mean value set for the innovation index proposed in the study, suggesting that the country can be considered the innovation leader of 2017 from among the countries investigated. The last (35th) place in the ranking was occupied by Ukraine.

Keywords

innovation, standards, ISO 9001, ISO 14001, ISO 27001, ISO 50001, ISO 22000, ISO 13485

JEL Classification

L15, O31, Q56

INTRODUCTION

Porter claims that competitiveness is linked to an industry's ability to both introduce innovations and implement improvements (Porter, 1993). At the same time, politics, company management and innovation strategists are more and more interested in standardization (Blind, 2009; Hajduk-Stelmachowicz, 2014; ISO Survey, 2018; Chudy-Laskowska, 2019). According to literature, wide analysis is important to better recognize and measure the impact of standardization on innovation activity and market (Scapolo et al., 2015).

The relevance of standardization as a crucial element to stimulate and empower innovation and competitiveness in Europe is strongly highlighted in 'EUROPE 2020: A strategy for smart, sustainable and inclusive growth' (COM (2010) 2020 Final, 3 March 2010). The use of norms is still voluntary, although harmonized European Standards remain part of the regulatory framework within the context of the

'New Approach', which is important to establish the European Single Market (www.newapproach.org). What is essential throughout the world is that the international norms obtain significance through the Agreement on Technical Barriers to Trade of the World Trade Organization (Büthe & Mattli, 2011).

Adoption of quality norms can be considered an innovation (Guler et al., 2002) and also a source of innovation. Based on the assumptions of the Innovation Diffusion Theory (Rogers (2010) for a review), it can be assumed, by analogy, that implementation of other worldwide standards such as ISO 14001, ISO 27001, ISO 50001, ISO 22000, ISO 13485 can also be regarded as forms of innovation activities, innovations and new sources of innovations. To understand this better, according to the Innovation Diffusion Theory, there are two types of participants in the process of innovation diffusion: one of them is the organization that is going to implement the innovation, while the second one involves everybody who is going to use the innovation (Rogers, 2010; Tornatzky & Klein 1982; Manders, 2014).

However, it is still not clear whether the ISO 9001, ISO 14001, ISO 27001, ISO 50001, ISO 22000, ISO 13485 certifications foster or hinder innovation activities in different countries, as so far this subject has not been discussed by scholars very often. Mostly, the implementation and impact of ISO certification is investigated and explained at two various areas such the company level and employee level (Mourougan, 2015). The country level also seems to be very important. The national differences, specifically the level of economic development and national culture, also influence different attitudes to linking standardization and innovation activity (Manders, de Vries & Blind 2016).

The comprehensive innovation indices used so far, i.e. the Global Innovation Index or Summary Innovation Index, take into account its various dimensions and aspects. It seems reasonable to enrich the currently used innovation indices, such as the Summary Innovation Index, in such a way that they also cover issues related to ISO certification, which is recognized and available worldwide. This certification also plays an increasingly significant role in transnational supply chains. To fill the research gap, an original and easy-to-use indicator of the innovation activity of countries was proposed, which also considers selected issues of standardization; ISO 9001, ISO 14001, ISO 27001, ISO 50001, ISO 22000, ISO 1348. The grouping of countries on the basis of the features adopted for this study is a new idea. The results of this study are important in the context of analyzing the sources of the competitive advantages of individual countries, sectors or companies. They can be used, for example, to understand the essence of additional (informal or formal) regulations that will also significantly affect the competitive position in the future. Filling the research gap may also provide a basis for a more in-depth analysis of the barriers or, alternatively, the reasons for a better position of individual countries in trade on the global market.

1. LITERATURE REVIEW

The definitions of standardization and standards raise a lot of controversy (De Vries, 1997).

Standards (norms) are a direct result of standardization. There are many advantages of standardization (Swann, 2000; Jain et al., 2014; Poveda-Orjuela, 2019; Young et al. 2018). A very important issue is if standardization overall constrains or enables innovation (Swann, 2000; Swann, 2010; Swann & Lambert, 2010; Blind, 2013).

There are many definitions for innovation in literature. Some of them show the value of innovation activity as the background for renewal in all kind of organizations. (Adams et al., 2006, Bessant et al., 2005). The most crucial role of innovation activity is to create value and maintain the competitive advantage (Beragheh et al., 2009; Bochm & Frederick, 2010; Vit et al., 2015; Maier et al., 2015; Okrah & Hajduk-Stelmachowicz, 2020) 6 including advantages in productivity growth (Bilan et al., 2020), export performance (Braja & Gemzik-Salwach, 2019), employment and incomes

(Lewandowska & Stopa, 2020), improvement of business planning (Akimova et al., 2020).

According to some researchers, innovations specify the new introduction of concepts, knowledge, methods, and abilities that can guarantee boosted products and processes to catch different customer needs and market demands (Meissner & Kotsemir, 2016).

The literature review on standardization and innovation activity, covering the period between 1995 and 2020, shows a continually increasing number of publications (Swann, 2010; Choi et al., 2011; Narayanan & Chen, 2012; Brem et al., 2016; Blind et al., 2018; Egyedi & Widlak, 2019; Karničar Šenk & Roblek, 2019). Most publications still focus on management, business and economics or environmental standards (Choi et al., 2011), and standardization and innovation are being investigated at different levels (Tamura, 2013; Lim & Prakash, 2014).

The traditional view has always been that norms and innovation are in conflict with each other. They are seen as antithetical processes (Thompson, 1965; Fixson & Park, 2008; David & Rothwell, 1996; Wright et al., 2012; Naveh, 2018). The aim of standardization is to achieve growth through economies of scale by improving productivity and increasing market share, while the aim of innovation is to help the producer become more profitable and responsive to market dynamics (Wang et al., 2016).

Placing standards on one side and novelty on the other may create some conflicts (Pesämaa, 2017). According to Van de Ven (1986), as long as an idea is regarded as new by the people concerned, it is an 'innovation', even if other people may claim that it is an 'imitation' of something that exists elsewhere. Innovation and standardization are complementary to each other (Kondo, 2000), so it is incorrect to say that the space left for innovative work tends to be reduced with the growth of work standardization.

When analyzing the links between the different levels of control and their nature, the researchers concluded that process and management innovations can coexist with the standardization of these processes. This is an important observation because it refutes the traditional view that standardization implies organizational control, which hinders the introduction of innovations (Zarzycka et al., 2019).

Standardization and innovation have a beneficial effect on the mass customization capability, both at individual and interactive levels. Furthermore, mass customization capability and innovation accelerate the speed of delivery. In addition to this, standardization and innovation indirectly affect the speed of delivery through the mass customization capacity (Wang et al., 2016).

The latest literature on the subject emphasizes the importance of standardization in the contemporary world from the political point of view, based on various perspectives: The results of the standardization process are of major relevance to the internalization of external factors and the successful liberalization of international trade. Standards reduce transaction costs (Funk & Luo, 2015) and facilitate trade, especially of complex products in the production chain and across borders (Hajduk-Stelmachowicz, 2013).

Researchers have shown the fundamental impact of standardization and innovation on the growth and welfare of our economies (Blind & Jungmittag, 2008). At the macro level, the positive impact of standards on the diffusion of innovation has been confirmed (Narayanan & Chen, 2012). Tassey introduced standardization as infratechnology (Tassey, 2000). In the case of industrialized and newly industrialized countries, there is a need to emphasize and analyze the role of standardization in increasing the competitiveness of their economies. Some countries (Canada, the UK, the USA, China, Germany, Japan, and Russia) have implemented national standardization strategies (Blind & Mangelsdorf, 2016). Standards can supplement or complement governmental regulations. The results of Blind's research indicate that standards can contribute to the optimization of public procurement procedures and support the public procurer in the decision-making and risk management processes, also by highlighting the importance of standards and intellectual property rights in a competitive market (patents, standards and legal issues). Standards can be perceived as an effective leveraging and diffusion mechanism for intellectual property rights. A recently emerging field addresses the role of standards and standardization in public procurements, which increasingly focus on introducing and promoting innovation (Blind, 2009, 2013; Blind et al., 2011).

Some authors have analyzed the relationships, new trends and challenges between innovations and standardization (Kim et al., 2012; Viardot et al., 2016; Hajduk-Stelmachowicz, 2016; Pacana, 2018; Naveh, 2018).

At this point, the challenge that needs to be faced is that of the effective and efficient use of standardization to stimulate innovation. According to the European Union policy, standards should serve the purpose of improving public procurement procedures and support the public procurer in taking decisions and managing risks in the future. The various potentials of standards should be developed very quickly for research purposes, and this will entail the need for continuous standardization forecasting. (Goluchowicz & Blind, 2011). As the results of empirical analyses, involving German companies for the purposes of the Community Innovation Survey, show, success in product innovation and standardization is an important parameter in measuring companies' success in competing for public procurements. Given the growing importance of standards in the context of participation in tenders (Europe Innova, 2008), a company's competitive advantage in securing and benefiting from such contracts will be partly determined by its awareness and ability to implement standards (Lorenz et al., 2009; Blind et al., 2020). Standards force competition and thus exert an innovative pressure on the participants in public tenders.

For many years, innovation policy has been centered on promoting the development of innovation. The factors that determine the demand for innovation and, consequently, the innovation policy in the aspect of demand, are currently being given particular attention (Edler, 2016). As far as demand is concerned, the policy on eco-innovation, as well as the role of the public sector in the pursuit of standardization and application of standards, should be clear. Influencing regulations via standardization seems to be crucial not only for organizations, but also for countries. Standardization can be seen as a business/country competition strategy, because it has an impact on technology and organizational standards in the market competition (there is a relation between technology, product life cycle, and innovation and standards) (Wright et al., 2012; Hajduk-

Stelmachowicz, 2014; Fura & Wang, 2017). It influences the business performance, development and norms.

2. AIMS AND RESEARCH METHODOLOGY

The results of studies that refer to the relationship between the innovation index of a given country (according to the European Innovation Scoreboard for the year 2017) and the level of saturation with certificates (confirming the functioning of selected management systems) recommended by the International Organization for Standardization have been shown. Despite many studies and because of the comprehensiveness and complexity of the phenomena, the following questions still remain valid: Which are the most innovative countries? What makes a country a benchmark for innovation?

The aim of the paper is: 1) to analyze the connection between the Summary Innovation Index (SII) and the components (features) related to innovation activity; 2) to investigate the variation of selected countries with reference to innovation activity in the year 2017, using the innovation activity index proposed by the authors.

The aim of this paper is, therefore, to check the relationships between the components of the innovation index of an economy according to the European Innovation Scoreboard, and the features that determine the innovation level in the investigated countries (with particular consideration given to those indices which refer to the index of the number of ISO 9001, ISO 27001, ISO 14001, ISO 50001, ISO 22000, and ISO 13485 certificates).

In this paper, an attempt has been made to investigate whether it is right to assume that countries with very low innovation have, at the same time, a very low level of saturation with globally recognized certificates that confirm the implementation, functioning and improvement of selected types of management systems (recommended by the ISO). Furthermore, the paper seeks to determine whether there are relationships between the SII and other features that determine the innovation level in the investigated countries, and, if so,

how strong those relationships are. In particular, an attempt has been made to establish links between the SII and the indicators, which refer to the respective types of ISO certificates. This scientific problem has not been sufficiently researched to date and is still largely ignored in combination with standards.

The data regarding the number of the specific types of ISO certificates in the respective European countries in the year 2017 have been obtained from the following website: <https://www.iso.org/the-iso-survey.html>. They are publicly available in the yearly issue of the ISO Survey 2018. Every year, the International Organization for Standardization performs a survey that shows the number of valid certificates, according to ISO standards for management worldwide. This is a way of counting the number of certificates issued by certification bodies that have been accredited by the International Accreditation Forum (IAF). It should be remembered that ISO (as independent, non-governmental international body) itself does not grant certification (<https://www.iso.org/about-us.html>, 2020).

The data that refer to the size of the population in the respective countries were obtained from the Eurostat database available at <https://ec.europa.eu/eurostat/web/population-demography-migration-projections/data/database>.

The data that express the innovation indices for the respective countries in the year 2017 were obtained from the European Innovation Scoreboard. They are available at https://www.ewi-vlaanderen.be/sites/default/files/imce/eu_innovatie_scorebord_2018.pdf.

The study involved the use of different indicators that characterize different innovation areas. The selection of indicators analyzed in this paper was based on the innovative activity of the entities and not the innovations per se (Geodecki, 2008). The innovation performance of a given country according to the European Innovation Scoreboard for the year 2017 (European Commission 2018, European Innovation Scoreboard 2018) was referenced to the numbers of ISO 9001, ISO 14001, ISO 27001, ISO 50001, ISO 22000 and ISO 1348 certificates per 100,000 inhabitants.

The analyses presented in this publication were performed using the Statistica 12 package. The basic descriptive statistics of components adopted for the study, the analysis of the correlations, the mid-rank method, the Ward's method and the Kruskal-Wallis ANOVA test were used in the elaboration.

3. RESULTS AND DISCUSSION

While analyzing the basic descriptive statistics (Table 1) of quality management systems, it must be pointed out that, on average, there were 57.83 ISO 9001 certificates per 100,000 people in the period under analysis. From the point of view of the analyzed perspective, the smallest numbers of certificates were issued in Ukraine (3.07), Turkey (7.68) and the Former Yugoslav Republic of Macedonia (21.41), while the largest numbers were issued in Italy (161.16), Switzerland (121.76) and Cyprus (109.85).

The average number of ISO 14001 certificates per 100,000 people in the analyzed countries was 22 (21.72). Given the mean value, the certification of environmental management systems was the least popular in Ukraine (0.53), as well as in Turkey (2.51) and Poland (7.60). The countries that were distinguished by the largest mean number of analyzed formal organizational eco-innovations included: Sweden (64.89), Estonia (42, 72) and the Czech Republic (40.76).

In the countries subjected to analysis, there were, on average 3 (3.02) certificates, which confirmed the compliance of the functioning of an organization with the requirements of ISO 27001. Among the three countries where the average number of Information Security Management certificates was the highest per 100,000 people were Iceland (17.73), United Kingdom (6.84) and Greece (6.75). On average, the smallest number of certificates for the analyzed system was issued in Ukraine (0.11), followed by France (0.51) and Turkey (0.67).

In reference to the average number of certificates for energy management systems, which amounted to 2 (2.31) in the investigated countries, it must be noted that, on average, the largest numbers of documents per 100,000 people, confirming com-

Table 1. The basic descriptive statistics of components adopted for the study – 2017

Source: Own elaboration.

Innovation Dimensions	Mean value	Me	Min.	Max.	Standard deviation	V _z
Summary Innovation Index	0.44	0.40	0.14	0.81	0.17	38.37
ISO 9001	57.83	53.67	3.07	161.16	31.65	54.74
ISO 14001	21.72	21.78	0.53	64.89	12.33	56.74
ISO 27001	3.02	2.03	0.11	17.73	3.07	101.51
ISO 50001	2.31	1.07	0.00	14.56	3.09	134.12
ISO 22000	2.79	1.48	0.23	24.92	5.16	185.21
ISO 13485	2.21	1.69	0.05	11.90	2.25	101.83
Human resources	0.47	0.46	0.09	0.94	0.22	46.41
Research systems	0.46	0.40	0.09	0.99	0.26	56.68
Innovation-friendly environment	0.51	0.49	0.02	1.00	0.25	49.12
Finance and support	0.43	0.39	0.04	0.85	0.24	55.40
Firm investments	0.42	0.40	0.05	0.96	0.19	43.98
Innovators	0.46	0.49	0.00	0.92	0.26	55.97
Linkages	0.42	0.37	0.05	0.77	0.20	48.90
Intellectual assets	0.35	0.32	0.04	0.72	0.22	60.89
Employment impacts	0.50	0.50	0.03	0.89	0.20	39.55
Sales impacts	0.47	0.49	0.17	0.85	0.18	38.92

pliance with the requirements of ISO 50001, were issued in Luxembourg (14.56), Germany (10.07) and Latvia (7.28). Based on the analyzed perspective (on average), the smallest numbers of ISO 50001 certificates were issued in Iceland (0.00), Turkey (0.21) and Romania (0.24).

While analyzing the number of food safety management systems, it must be pointed out that, on average, there were 3 (2, 79) ISO 22000 certificates per 100,000 people in the period under analysis. From the point of view of the analyzed perspective, the smallest numbers of these certificates were issued in the United Kingdom (0.23), Germany (0.50) and Ukraine (0.50), while the largest numbers were issued in Cyprus (24.92), Greece (21.22) and Bulgaria (3.68).

On average, 2 (2.21) ISO 13485 certificates per 100,000 people were issued in the investigated countries. On average, the largest numbers, i.e. 12 (11.90), were issued in Switzerland. Germany (6.98), Italy (4.57) and Norway (4.03) were also in the lead. In the analyzed period, with respect to the average number of certificates issued based on the standard “Medical devices – Quality management systems – Requirements for regulatory purposes”, the following countries were placed at the bottom of the ranking: the Former Yugoslav Republic of Macedonia (0.05), Ukraine (0.05) and Turkey (0.07).

Standard deviations and variability coefficients indicate a high variation of all features considered in the studies among the countries included in the analyzed group. The majority of features are characterized by right-sided asymmetry, which means that the investigated features in the majority of countries had lower values than the average value. An exception to this rule includes three indicators, where the distribution is characterized by left-sided asymmetry – these are: ISO 9001, Innovators and Sales Impact, so in most of the countries, the above-mentioned indicators were higher than average in the analyzed period.

The relationships between various types of indicators, which refer to the ISO certification and SII, were subjected to verification. The correlation coefficients between the respective types of ISO certification are not high, and the closest relationship is between the certification for compliance with the ISO 9001 requirements and ISO 14001 requirements. The correlation coefficient is 0.46, which means that the investigated variables depend on each other (affect each other) at a level of 46%. Along with an increase in the number of management system certificates per 100,000 people, the number of certified environmental management systems per 100,000 people also increases.

It must also be mentioned that the relationship between SII and the ISO 9001 certification is the

weakest. It can even be said that it is very weak (0.12). Also, the relationships between the SSI and ISO 27001 certification and between the SSI and ISO 50001 certification are very weak. There is also one indicator that had a negative correlation with SII – ISO 22000 (Table 2).

Table 2. Correlation between different types of ISO indicators and SII

Source: Own elaboration.

Innovation Dimensions	Summary Innovation Index
ISO 9001	0.12
ISO 14001	0.31
ISO 27001	0.14
ISO 50001	0.22
ISO 22000	-0.18
ISO 13485	0.70

The correlation coefficients indicate that the closest relationship is between SII and ISO 13485. The correlation is positive and amounts to 0.7, which means that the relationship between the investigated indicators is strong. This means that as the number of ISO13485 certificates increases, the SII value increases proportionately. These features are modelled at 70%.

The regression equation that describes this relationship has the following form: $Y = 0.32 + 0.05X$. This can be interpreted as follows: if the number

of certificates related to management based on ISO123485 increases by 1 per 100,000 inhabitants, the value of the SII will increase by 0.05 point. This is quite a surprising and interesting conclusion. (Figure 1 and Figure. 2).

Based on the results of the quoted studies, the conclusion may be drawn that certification and operation of the management systems in the medical sector based on the international standard – ISO13485 – has a positive impact on the increase in innovation level. In the age of SARS-Covid 19, where individual companies and countries are spending valuable time looking for new, effective and innovative solutions (in response to the multi-faceted challenges of the contemporary world), the certification and standardization of the medical sector will be a more and more significant component that affects an increase in competitive advantage.

Next, the relationships between the SII and other indicators that determine the innovation dimensions analyzed in this paper were investigated (Table 3).

Analysis of correlations demonstrates that the SII has the closest relationship with Research systems, and this correlation is positive and almost complete (0.92). This means that as the Research sys-

Source: Own elaboration.

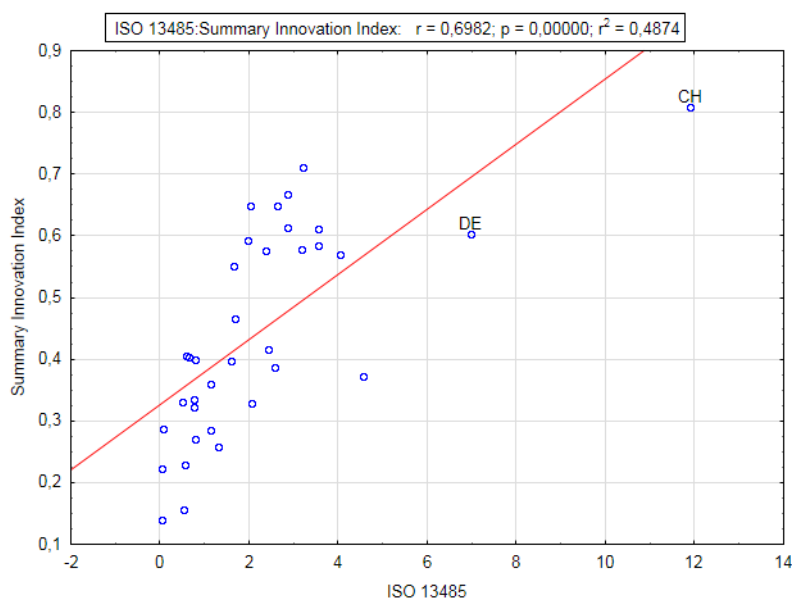
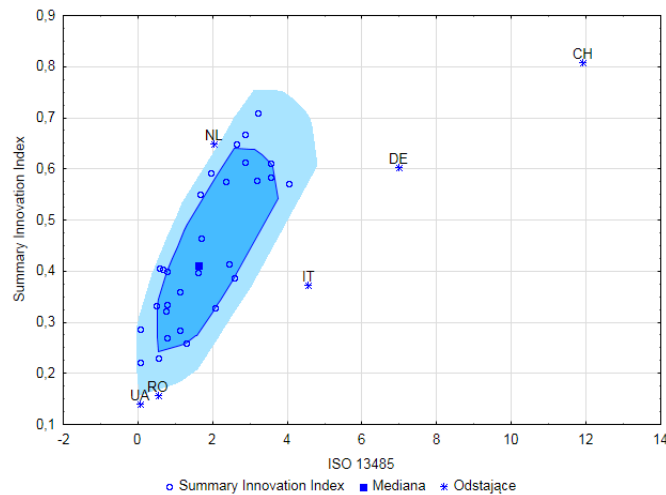


Figure 1. Scatter plot between ISO 13485 and SII

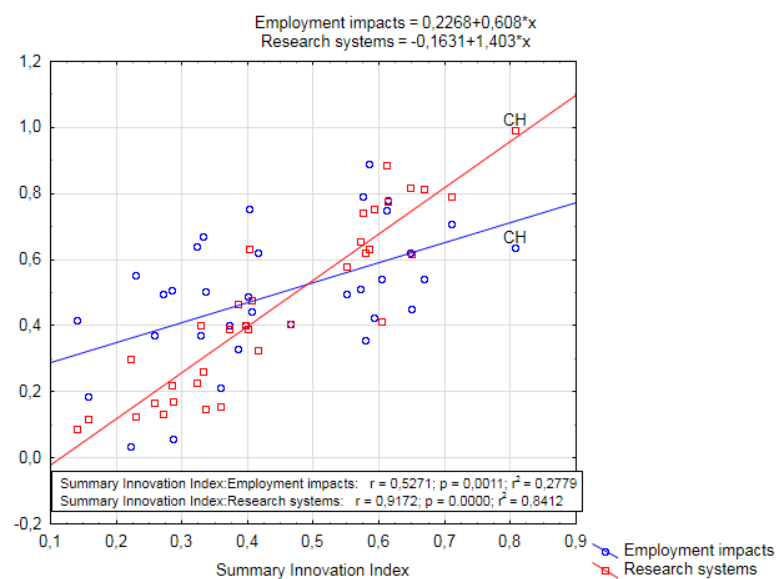
Source: Own elaboration.

**Figure 2.** Bagplot between ISO 13485 and SII**Table 3.** Correlation between the SII and innovation dimensions

Source: Own elaboration.

Innovation Dimensions	Summary Innovation Index
Human resources	0.86
Research systems	0.92
Innovation-friendly environment	0.74
Finance and support	0.82
Firm investments	0.73
Innovators	0.82
Linkages	0.82
Intellectual assets	0.72
Employment impacts	0.53
Sales impacts	0.61

Note: Correlation between the SII and innovation dimensions.

**Figure 3.** Scatter plot between SII and Research Systems

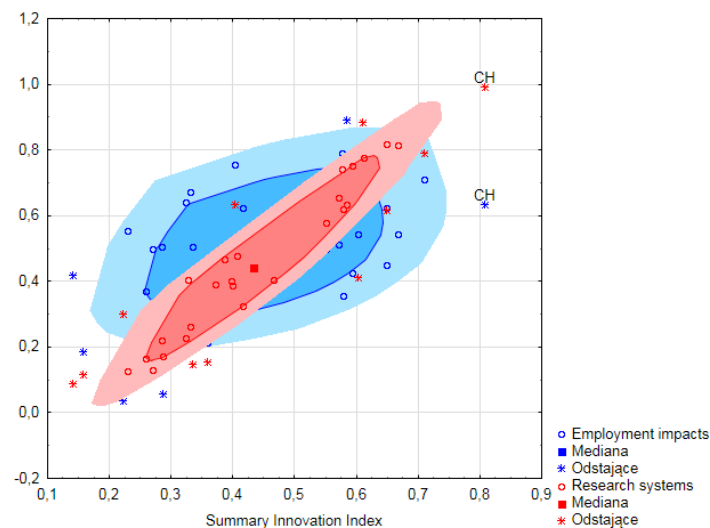


Figure 4. Bag plot between SII and Research Systems

tems dimension increases, so does SII (Figure 3 and Figure 4).

In terms of the strength of the relationship with the SII, the sequence of indicators was as follows: Human resources (0.86), Innovators (0.82), Linkages (0.82), Finance and support (0.82), Innovation-friendly environment (0.74), Firm investments (0.73), Intellectual assets (0.72), and Sales impacts (0.61). The range of variability of the correlation coefficients in the case of the indicators mentioned above indicates a positive correla-

tion – very high or high in the last of the mentioned cases.

The weakest relationship – though still strong – is between the SII and the Employment impact indicator (0.53). It is also positive and directly proportionate.

Based on the selected features (excluding the SII), countries were categorized according to their levels of innovation activity. The results of the grouping have been presented in diagram (Figure 5). The

Source: Own elaboration.

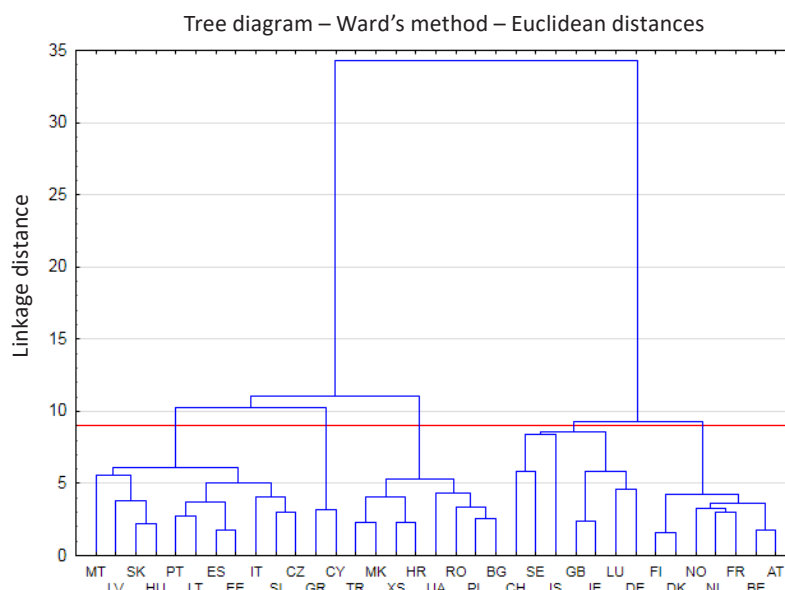


Figure 5. Countries grouping results

division of the diagram indicates that five groups of countries, similar to each other in terms of certain features that determine the innovation performance in a given cluster, were created.

Group A consisted of: AT – Austria, BE – Belgium, FR – France, NL – Netherlands, NO – Norway, DK – Denmark, and FI – Finland. Nearly 63% of all the components analyzed in this group take values higher than the average. The levels of the indicators referring to the ISO 14001 and ISO 9001 certifications were lower by about 1/3 than the average level. The certification levels of energy management systems according to ISO 50001, as well as information security management systems according to ISO 27001 and also the certification of systems based on requirements of ISO 22000, were roughly at a level that oscillates around half of the average. The level of the Finance and support indicator was higher than the average by nearly 2/3 in this group. The following indicators were approximately 1.5 times higher in this analyzed group of countries: Research systems, Linkages, Innovators. At a level that oscillates around the average value were the values of indicators that referred to the certification of systems based on ISO 13485, i.e. Firm investments, Sales impacts and Employment impacts.

Group B consisted of: DE – Germany, LU – Luxembourg, IE – Ireland, GB – United Kingdom, IS – Iceland, SE – Sweden, and CH – Switzerland. In this cluster, the level of 94% of analyzed features is significantly above the average value calculated for the group of all investigated countries. Only the indicator that refers to the number of ISO 22000 certificates is lower by almost 2/3 than the average (and its value is the lowest among the indicators from the analyzed cluster). In this group, the certification of energy management systems based on ISO 50001 and the certification based on ISO 13485- Medical devices – Quality management systems – Requirements for regulatory purposes exceeds the global average by more than double. Information management systems based on ISO 27001 are certified here almost twice as often (a similar relationship is also characteristic of group D). The environmental management systems based on ISO 14001 are certified in the investigated cluster almost 1.5 times more

often than the average. The following indicators were approximately 1.5 times higher than the global average in this analyzed group of countries: Research systems, Innovators, Finance and support, Employment impacts, Human resources. As opposed to other clusters (with respect to the value of indicators), group A looks the best.

Group C consisted of: BG – Bulgaria, PL -Poland, RO – Romania, UA – Ukraine, HR – Croatia, XS – Serbia, MK – The Former Yugoslav Republic of Macedonia, and TR – Turkey. In the context of the conducted analysis, when compared to other clusters, this group seems to achieve the worst results. All the indicators (100%) in this group of countries, which are the subject of this paper, are well below the average level (they oscillate around half of this level). The indicator for the feature, which is related to the ISO 22000 certification, is the closest to the average. The frequency of certification of quality management systems based on ISO 9001, the frequency of certification of environmental management systems according to ISO 14001 and information management systems according to ISO 27001 are approximate in this cluster (they are at a level which reaches more or less 2/3 of the average). In this group of countries, the levels of indicators referring both to the certification of management systems in the medical sector based on ISO 13485, and the universal energy management systems based on ISO 50001 are the lowest in relation to the average level (they are at a level which approximates one third of the average value). The level of the indicator for the component referred to as Innovation-friendly environment (in this group it approximates the level established for the countries belonging to group A and group D) oscillates around the value of half of the global average. A similar situation is observed in reference to components such as Human resources, Linkages, Intellectual assets, and Sales impact. The levels of indicators for the Employment impact and Sales impact are slightly higher and approximate 2/3 of the average value. When comparing this cluster to the others, it is necessary to point out that it is actually this group of countries in which the level of the Innovators indicator is the lowest (0.39)

Group D consisted of: CY – Cyprus and GR – Greece. In this group, the certification of man-

agement systems based on ISO 22000 (important for the food industry) is over eight times above the average. The indicator which refers to the information security management systems according to ISO 27001 was set at a level which approximates 2/3 of the average. The level of the indicator referring to the quality management system is approx. 1.5 times higher than the average level. At levels which oscillate around the global average, there are indicators of such features as: certification based on ISO 13485, certification of the environmental management system according to ISO 14001, Innovators, Research System, Intellectual assets, Linkage and Human Resources. The indicators with values ranging around half of the average were assigned in the discussed cluster to: ISO 50001, Firms Investments and Finance and Support. The lowest value in group D was observed for the indicator referred to as Innovation-friendly environment – 0.42.

Group E consisted of: CZ – Czech Republic, SI – Slovenia, IT – Italy, EE – Estonia, ES – Spain, LT – Lithuania, PT – Portugal, HU – Hungary, SK – Slovakia, LV – Latvia and MT – Malta. In this cluster of countries, only two partial indicators oscillate slightly above the average (the values of the rest, i.e. nearly 87% of components, are below the average level). These include ISO 9001 and ISO 14001 certifications. The indicators related to the Innovation-friendly environment, Sales impacts, Employment impacts, the energy management system certification based on ISO 50001, Intellectual assets, Firm investments approximate the average level. The level of the indicator for the certification of information security management systems based on ISO 27001 (0.84) is higher than in the cases of groups A and C. The levels of indicators such as Human Resources, Finance and support, Research Systems, Innovators range slightly above 2/3 of the average value. The following components oscillate around half of the average value indicator: ISO 13485 and ISO 22000.

Based on the selected features, a ranking of countries was also created, taking into account all the features as stimulants (the higher the value of an indicator, the better). For this purpose, the mid-rank method was used (Table 4).

Table 4. Ranking of the innovation activity of countries in 2017, created on the basis of features adopted for the study (the SII is not taken into account)

Source: Own elaboration.

Code	Country	Ranking
CH	Switzerland	1
SE	Sweden	2
NL	Netherlands	3
GB	United Kingdom	4
DK	Denmark	5
LU	Luxembourg	6
IS	Iceland	7
DE	Germany	8.5
IE	Ireland	8.5
FI	Finland	10
NO	Norway	11
CZ	Czech Republic	12
AT	Austria	13
BE	Belgium	14
CY	Cyprus	15
SI	Slovenia	16
FR	France	17
EE	Estonia	18
ES	Spain	19
HU	Hungary	20.5
IT	Italy	20.5
GR	Greece	22.5
SK	Slovakia	22.5
PT	Portugal	24
LV	Latvia	25
LT	Lithuania	26.5
MT	Malta	26.5
HR	Croatia	28
BG	Bulgaria	29
XS	Serbia	30
PL	Poland	31
RO	Romania	32
TR	Turkey	33
MK	The Former Yugoslav Republic of Macedonia	34
UA	Ukraine	35

Switzerland (a country from group B) obtained the highest mean value for the proposed innovation level, which allows concluding that this country could be considered the innovation leader from among the 35 investigated countries in the year 2017. Among the proposed and analyzed 17 indicators, which characterize the various areas of innovation, Switzerland was (among the countries subjected to the studies) the leader in the ISO 13485 certification per 100,000 inhabitants. The SII level was also the highest. Furthermore, this country was characterized by the highest level

of the following indicators: Innovators, Research systems, Firm investments and Human resources. It was ranked second with reference to the ISO 9001 certification, and third with reference to the Intellectual assets component. It occupied the fourth position when it came to the value of indicators such as Sales impacts and ISO 14001 certification per 100,000 inhabitants. The value of the Finance and support and Linkages components puts it in fifth place among the investigated countries. With respect to the level of the factor Innovation-friendly environment, Switzerland took sixth place (starting with Denmark, which was the leader in this respect, Switzerland was classified after countries such as Iceland, Sweden, Finland and the Netherlands).

The second position in the ranking was occupied by Sweden (group B). In 2017, the country was the leader when it came to the certification of organizational eco-innovations in the form of formal environmental management systems (per 100,000 inhabitants) based on ISO 14001. It also occupied the second position with respect to the Firm investments sub-indicator. It came third in terms of the value of such components as Human Resources and Innovation-friendly environment, and fourth in terms of the value of Intellectual assets. Sweden was also among the first five countries with respect to the high value of the Research systems indicator. The country was ranked seventh after calculating

the number of ISO 13485 certificates per 100,000 inhabitants, and only 26th when taking into account the ISO 9001 certification indicator.

The Netherlands (countries representing group A) took third place in the ranking, created using the proposed innovation index, taking into account the ISO certification. When analyzing the level of indicators for this country compared to other countries participating in the study, it must be noted that it is: in third place with respect to the value of indicators such as Research systems, Finance and support and Linkages; in fourth place with respect to the certification of information security management systems according to ISO 27001, in fifth place with respect to the Innovation-friendly environment indicator, and in eighth place with respect to the level of the certification based on ISO 22000.

It is also worth noting that according to the Global Innovation Index (GII) ranking, in the case of Europe, it is Switzerland, Netherlands and Sweden, which are the top innovation regions. A very interesting issue is that it is actually Switzerland that continually took first place in the GII ranking in the period between 2011 and 2018 (The Global Innovation Index 2018: Energizing the World with Innovation).

The last (35th) place among the analyzed countries in the ranking created on the basis of the innova-

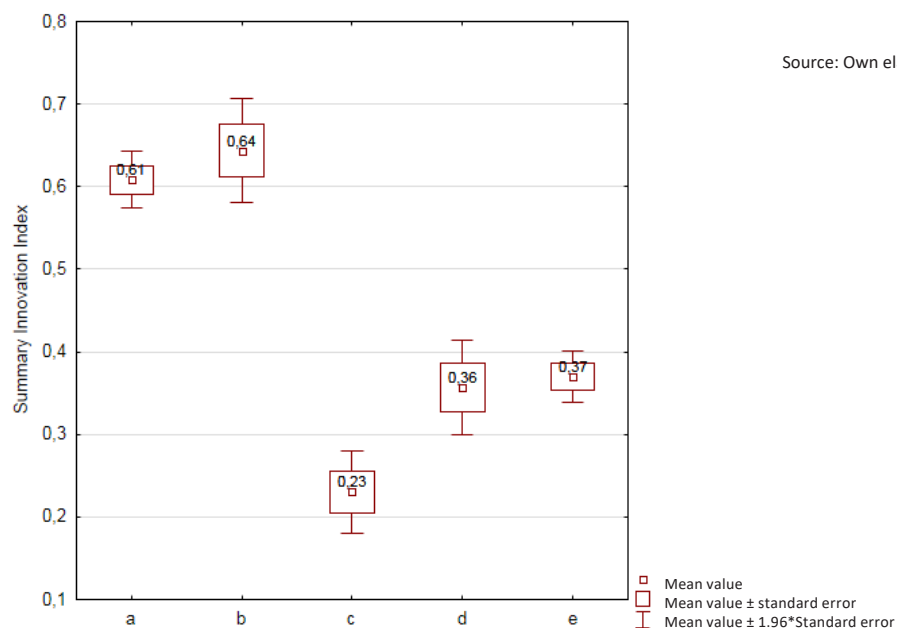


Figure 6. Mean values of the SII in the created clusters

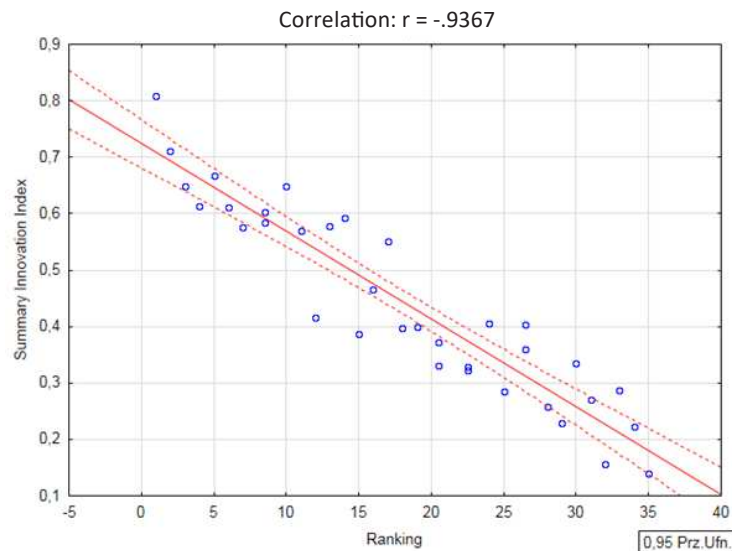


Figure 7. Relationship between the ranking of countries and the SII

tion index was occupied by Ukraine. When analyzing the level of indicators for this country (in comparison to the other countries covered by the study), it should be noted that it is: 1) the lowest for the following indicators under analysis: ISO 9001, ISO 14001, ISO 27001, Research systems, Innovation-friendly environment, Linkages; 2) penultimate, in the case of: ISO 13485, Finance and support and Intellectual assets; 3) third from last when taking into account the following indicator: Firm investments, ISO 22000. The best (though in just the 15th position in the indicator ranking) was obtained by Ukraine with regards to the value of the Human resources indicator.

Comparison of the grouping with the ranking and the SII – The Kruskal-Wallis ANOVA test

was used to investigate whether there are differences in the value of the SII as broken down into the created clusters. The studies demonstrate that $p < \alpha$ ($p = 0.00000$), so the differences are statistically significant. The highest SII is characteristic of countries from Group B, a slightly lower index can be observed in countries from Group A, and the lowest values of SII are found in Group C (Figure 6).

Also, the compliance of the ranking drawn up on the basis of selected features was investigated with reference to the Summary Innovation Index.

The relationship is very strong and confirms the compliance of the value of the index and the created ranking.

CONCLUSION

Analysis of the relationships between the SII and other configurations of features that determine innovation performance in different countries was conducted. The new ranking of countries on the basis of features (new index) considered for the study (without the SII) is added value of this elaboration. The used methodology allows for the expansion of the indicators used so far, which refer to the innovative activity associated with standardization.

According to the research results, it is right to assume that analyzed countries with very low innovation activity have, at the same time, a very low level of saturation with globally recognized certificates that confirm the implementation, functioning and improvement of selected types of management systems (recommended by the ISO). It can be confirmed that ISO standardization had an impact on innovation activity in the analyzed 35 countries in 2017.

For many years, standardization was often perceived as a contradiction of innovation. According to the results of this study, the implementation of standardization can be seen as an innovation tool. What is more, standardization does not impede innovation. The application of standards (including reliable and independent certification) can provide a basis for innovation diffusion (factor, network) as it acts as a channel for knowledge transfer.

Nowadays, standardization is not yet the powerful transfer tool it could be. The level of standardization can be considered as one of the indicators of sustainable development in the circular economy. Standardization can support the achievement of economic, ecological and social goals, which can, in turn, support sustainable development.

The conclusions from own studies are:

- 1) standardization can be regarded as a tool for strengthening innovation;
- 2) as a result of an increase in the number of quality management system certificates, the number of certified environmental management systems also increases (per 100 thousand people);
- 3) an increase in the number of ISO13485 certificates translates into an increase in the value of the SII. The features are subject to modelling at the level of 70%;
- 4) the relationship between SII and the ISO 9001 certificate is the least visible. Moreover, there are very weak relationships between SII and ISO 27001 certification and between SSI and ISO 50001;
- 5) among the countries in group B, the highest average value of the innovation indicator presented in the study was reported in the case of Switzerland, therefore, it can be argued that, among the surveyed countries, this country can be counted among the innovation leaders in 2017. Finally, the last (35th) place in the ranking among the discussed countries was awarded to Ukraine. While analyzing the level of indicators for this country (as compared to other investigated countries), it must be noticed that it is: 1) the lowest for the following indicators: ISO 9001, ISO 14001, ISO 27001, Research systems, Innovation-friendly environment.

The interrelationship between standardization and innovation should be an area of further research – the issue is multidimensional and multifaceted.

AUTHOR CONTRIBUTIONS

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Visualization: Urszula Mentel, Marzena Hajduk-Stelmachowicz.

Writing – original draft: Urszula Mentel, Marzena Hajduk-Stelmachowicz.

Writing – review & editing: Urszula Mentel, Marzena Hajduk-Stelmachowicz.

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