

## INSTRUMENTS USED TO IMPROVE THE BETTERMENT OF PRODUCTS QUALITY

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**Purpose:** The main goal of the research was to determine the spectrum of instruments supporting management processes that are used to improve the quality of products in terms of sustainable development. We analyzed the degree of their use in the practical functioning of the surveyed enterprises. In addition, the aim of the research was to determine the scope of application of the indicated instruments or the possibility of their use in the decision-making process relating to the improvement of the broadly understood quality of products.

**Design/methodology/approach:** The research method applied are: 1) standardized survey research making based on a survey conducted in contact and remote way conducted in 78 enterprises in south-eastern Poland; 2) analysis of the source documentation and in-depth interviews. It is a component of broader research.

**Findings:** The following methods were used in decision-making processes with varying frequency: the Delphi method by 58% of respondents, Tree of Failure Analysis (by 52%), Event Tree Analysis (by 44%), and the QFD method (by 41% respondents). The surveyed companies that have implemented a vapour management system based on ISO standards tend to use 5 methods out of 25 cited in this study (these are a survey, brainstorming, 5Why and/or 5W2H, benchmarking, and the Delphi method). As a result of using mainly the above-mentioned methods in decision-making processes, 74% (out of all) of the respondents indicated an increase in the quality level of products, and 39% of respondents indicated the enhancement of the pro-ecological impact of products on the natural environment.

**Research limitations/implications:** Most of the analysed enterprises from SMEs are tried integrating qualitative-environmental actions as part of improving the quality of products. This approach is crucial when improving the quality of products in SMEs.

**Practical implications:** It is necessary to develop a multidimensional model enabling the optimization of decision-making processes with the possibility of making full use of the available instruments for improving the quality of the product in such a way as to meet the rapidly changing requirements of stakeholders.

**Originality/value:** The article has cognitive value for development of knowledge, science, quality, and environmental in the area of management of products.

**Keywords:** quality management, sustainable decision support, production engineering, quality of products, mechanical engineering.

**Category of the paper:** Research paper.

## 1. Introduction

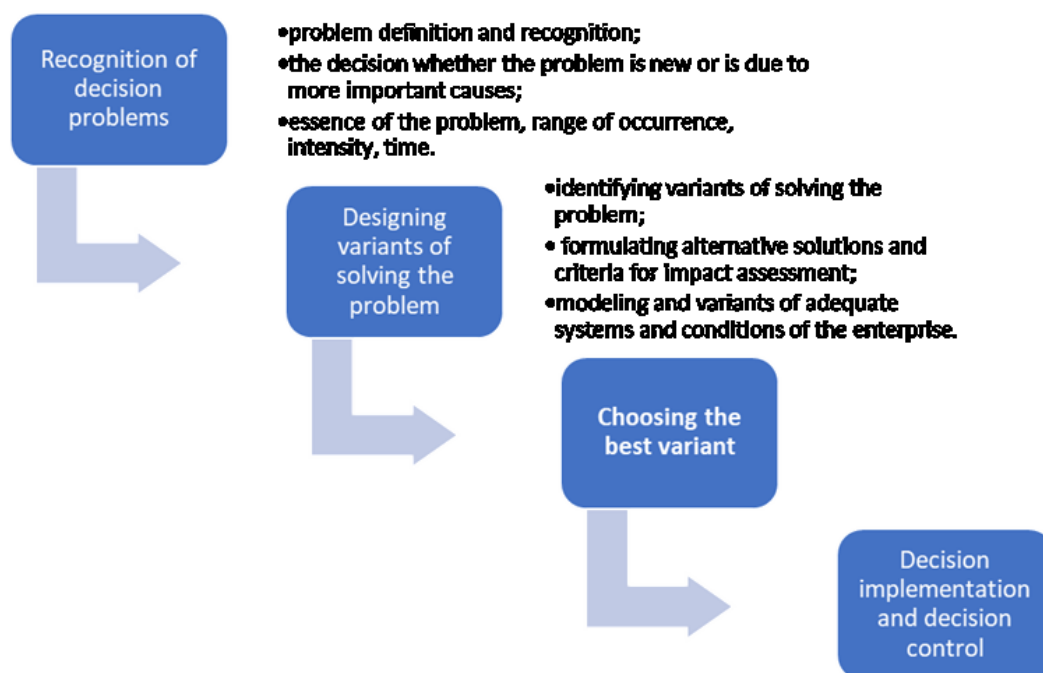
The beginning of the 20s of the 21st century is characterized by an extraordinary, fast and difficult to define pace of changes. (Migala-Warchoł, 2021). Additional challenges were reinforced by the consequences of the Covid-19 epidemic and the Russia-Ukraine war. The effects of these events are visible in the social, political, and economic life of all countries, in particular, Poland (Piecuch, Chudy-Laskowska, Szczygieł, 2019). Therefore, optimal (usually understood as rational) decision-making in the process of the so-called green management is gaining more and more importance. It should take into account the impact of sustainable development not only on the work of engineers in the design of products but also on their entire life cycle following the idea of "cradle to grave" (Wyrwa, Ziółkowski, 2015).

The topic is important at the micro, meso and macroeconomic level and is important not only at present, but also relates to the future of, for example, technical and engineering solutions. It is one of the global challenges (Deqiang Zhijun, Hajduk-Stelmachowicz, Larik, Rafique, 2021). There is a need for cooperation between theoreticians and practitioners representing a broad spectrum of scientific fields in order to develop implementable solutions that bring the widely understood synergy effect to production processes. Especially in view of the latest challenges adopted for implementation by the European Union under the so-called circular economy is an important and current topic (Ferreira Gregorio, Pié, Terceño, 2018). In this study, the authors attempted to indicate the instruments used to improve the quality of products in SMEs.

## 2. Decision-making process in enterprises

The primary condition for making a decision at each stage of business management should be a correct, detailed analysis of the problem with all its aspects (Gunther, 2008; Davenport, 2011). A significant role in the decision-making process is played by the proper boundary conditions defining. They should precisely define what procedures have to be followed and indicate the available and necessary means, resources, and implementation time of a given project (Drucker, 2005). In the conditions of the presence of many rapidly changing input data to the process (including numerous determinants of the external and internal environment), the decision-making process – especially un-programmed one – becomes a challenge for decision-makers.

The starting point of any decision-making process is the arises of a decision-making situation, which can be defined as a change in the state of affairs in the functioning of the enterprise as a whole or its subsystems. Regardless of the procedures that may be used when making decisions, one can indicate constant elements of the decision-making process (Brzeziński, 2007). Their diagram is shown in Figure 1.



**Figure 1.** Elements of the decision-making process. Source: own study based on: Griffin, 1996; Stoner, Wankel, 1996; Brzeziński, 2007.

In scientific studies relating to the subject of management, the need to understand complex and multidimensional mechanisms related to the process of making right decisions is emphasized. The decision-making process is influenced by a large number of factors. They include, among others cognitive abilities, personality type, emotional state, views, attitudes, context (circumstances), presence of people (influence of other people) or lack thereof

(Okrah, Hajduk-Stelmachowicz, 2020). The literature on the subject emphasizes that the key in the 21st century is the increase in the ability of managers to make quick and accurate decisions, react to changes and create them. This pursuit of a better quality of its products leads to changes, referring to improving production processes, implementing innovation, and changes in organized character (Jonek-Kowalska, Wolniak, 2022).

Summing up, managers making the right decisions regarding the improvement of product quality should be based on several aspects, which include, among others, such (rational and irrational) components, such as e.g.:

1. Intuition – especially important when information, knowledge, experience, and methods used so far are not sufficient in the face of the need to solve problems in the conditions of cognitive difficulties, the so-called indeterminate/fuzzy decision situations (Jankowska-Mihułowicz, 2008; Adamkiewicz-Drwiłło, Jankowska-Mihułowicz, 2008).
2. Emotions – the importance of positive and negative emotions/emotional processes in the process of making managerial decisions (in conditions of uncertainty) is very significant in relation to the problematic content, e.g. posing a threat. In management sciences, emotions are treated as an irrational element, which means that they are considered potential risk factors (Jankowska-Mihułowicz, Chudy-Laskowska, 2019).
3. The use of appropriately selected instruments, including multi-criteria decision-making methods that are used in various areas of management (Czerwińska, Belch, Hajduk-Stelmachowicz, Siwiec, Pacana, 2021, Siwiec, Pacana, 2021).
4. Analysis of reports and information from, among others, from the accounting system, Business Intelligence systems, ERP class systems, own programs of enterprises, external and internal audits, integrated management systems).
5. Measurement of the company's achievements, including key success indicators.
6. Controlling analyses covering the area of production logistics (Belch, Belch, 2020; 2021).

The main components of multi-criteria decision-making tasks include (Mechitov, Moshkovich, Klimberg, 2022):

- alternatives (alternative decisions, options),
- criteria (attributes, characteristics),
- specific requirements for the final decision,
- a decision maker,
- experts,
- consultants (analysts),
- active social groups.

It is necessary to be aware that the so-called managerial decision-making is not only an intellectual attribute of managers of the strategic management level. It is also a manifestation of the charisma (knowledge and mindfulness) of lower-level leaders. In addition, it is an expression of readiness for continuous learning, high resistance to stress, high level of so-called ambiguity tolerance. It is a measure of proficiency in making correct multi-faceted decisions in various situations, and therefore also in specific conditions, in conditions leading to the need to manage change (this manifests itself in the form of, among others, information gaps, information obsolescence, or information chaos).

### **3. Research methodology**

The survey questions were developed on the basis of the literature review on the subject, e.g. (Ejdys, Kobylańska, Lulewicz-Sas, 2012; Ostasz, Siwiec, Pacana, 2022; Pacana, Siwiec, 2021; Siwiec, Pacana, 2021; Pacana, 2015; Świrk, 2020).

The survey questionnaires were sent to production companies from the Podkarpackie voivodship. Moreover, where possible, direct interviews were conducted (the so-called in-depth interviews with persons responsible for decision-making processes related to the improvement of the quality of products). The data collection stage was carried out in the first quarter of 2022. Ultimately, correctly completed questionnaires were obtained from 78 companies. The group was selected in a non-random, intentional manner, which is both an advantage and a disadvantage of this study. The methodology used resulted from the adopted goal of the work.

The researched companies were characterized on the basis of the following criteria:

- the size of the enterprise measured by the number of employees,
- company headquarters location,
- the degree of internationalization of economic activity,
- the implemented quality management system according to the international standard ISO 9001:2015,
- the implemented environmental management system based on the guidelines of ISO 14001:2015.

Taking into account the criterion of the size of the studied entities, it should be noted that the majority (58% and 18%, respectively) of the participants of the conducted research are medium and small enterprises. This fact results from non-random, deliberate sample selection. The structure of the respondents taking into account their size is presented in Table 1.

**Table 1.***The structure of the surveyed enterprises in terms of size*

The size of the enterprise	Number of enterprises	Percentage of enterprise
Large enterprises (over 250 employees)	12	15
Medium-sized enterprises (51-250 employees)	45	58
Small enterprises (10-50 employees)	14	18
Micro enterprises (1-9 employees)	7	9

Source: own study based on the results of research in enterprises. N = 78.

Another criterion for the selection of the research sample was the seat of the enterprise. In this case, the vast majority were entities located in urban areas. The distribution of research participants by the seat is presented in Table 2.

**Table 2.***The structure of the surveyed enterprises according to the seat of the enterprise*

The size of the enterprise	Number of enterprises	Percentage of enterprise
Rural area	24	31
Urban area	54	69

Source: own study based on the results of research in enterprises.

As part of the research, participants were also divided according to the scope of their activities. Thus, four categories of entities were distinguished: national, international, local, and regional enterprises. The distribution of the surveyed enterprises according to the scope of their activity is presented in Table 3.

**Table 3.***The structure of the surveyed enterprises in terms of the range of economic activity*

The size of the enterprise	Number of enterprises	Percentage of enterprise
Local	1	1
Regional	5	6
National	15	19
International	57	73

Source: own study based on the results of research in enterprises.

In addition, it was analysed whether the respondents had a quality management system compliant with the ISO 9001: 2015 standard and an environmental management system based on the requirements of the international standard 14001: 2015. The importance of these standards is emphasized in the context of a systemic and eco-innovative approach to management in the conditions of hyper-competition. The test results are presented in Table 4.

**Table 4.***Quality management system implemented*

Management system implemented	ISO 9001:2015		ISO 14001:2015	
	Number of enterprises	% of enterprises	Number of enterprises	% of enterprises
yes	53	68	27	34
no	19	24	45	58
in the course of implementation	6	8	6	8

Source: own study based on the results of research in enterprises. N = 78.

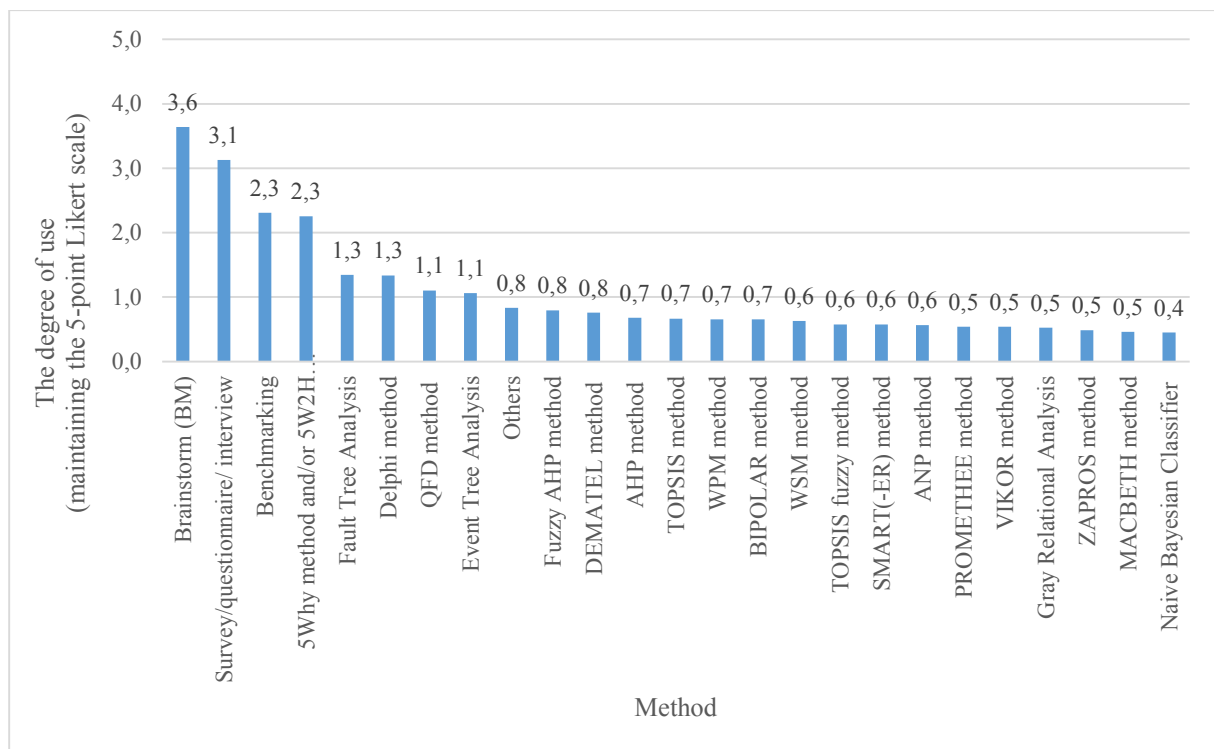
Most of the research participants were SMEs operating in international (73%) and domestic (19%) markets. Enterprises regionally operating constituted 6% of the respondents, and entities operating only in local markets constituted 1%. This research aimed to answer the question about what instruments are used by the surveyed entities in the decision-making process regarding the improvement of the broadly understood quality of products. Obtaining an answer to such a research question made it possible to determine to what extent and to what extent the methods/tools that support and optimize decision-making processes described in the literature are used. It is an extremely important topic in the context of the functioning of entities in a condition of an unstable environment.

#### 4. Results

In management and quality sciences and in economic practice, terms such as: methods, instruments, concepts, techniques, approaches or management tools are often treated as synonyms. Similarly, the lack of a universal approach to instruments supporting decision-making, can be indicated. In foreign literature, both terms are included in the category of management tools (DiLeo, 2019; Helmold, 2021; Velikikh, 2021; Bernardo, Rampasso, Quelhas, Leal, Filho, Anholon, 2022; Ostapenko, Kubetska, Olha, Antipova, 2020; Günter 2022; Dückers, Wagner, Groenewegen, 2008; Helmold, 2021). For the purposes of the article, according to the dictionary of the Polish language, the term "instrument" or "method" means a means to achieve something (PWN Dictionary of the Polish Language).

The degree of use/suitability of individual instruments recommended for improving the quality of products was determined, maintaining the 5-point Likert scale (Figure 2).

In the decision-making practice of production companies, the method of brainstorming was used very often. Only 5% (and rarely 3%) of the respondents have never used this method. The respondents declared that a survey and/or questionnaire form and/or an interview were often used. This method was never used by 12% (and rarely 9%) of the respondents. However, sometimes benchmarking and 5Why and/or 5W2H were used. The first of these instruments was never used by 27% of respondents (12% declared occasional use). Often, very often, or always, the benchmarking method was used by more than half (54%) of the respondents. The 5 Why method and/or the 5W2H method was/were never used or used occasionally by 36% and 6% of respondents, respectively. Often, very often, or always in the process of improving the quality of products, this instrument was used by 42% of the respondents.

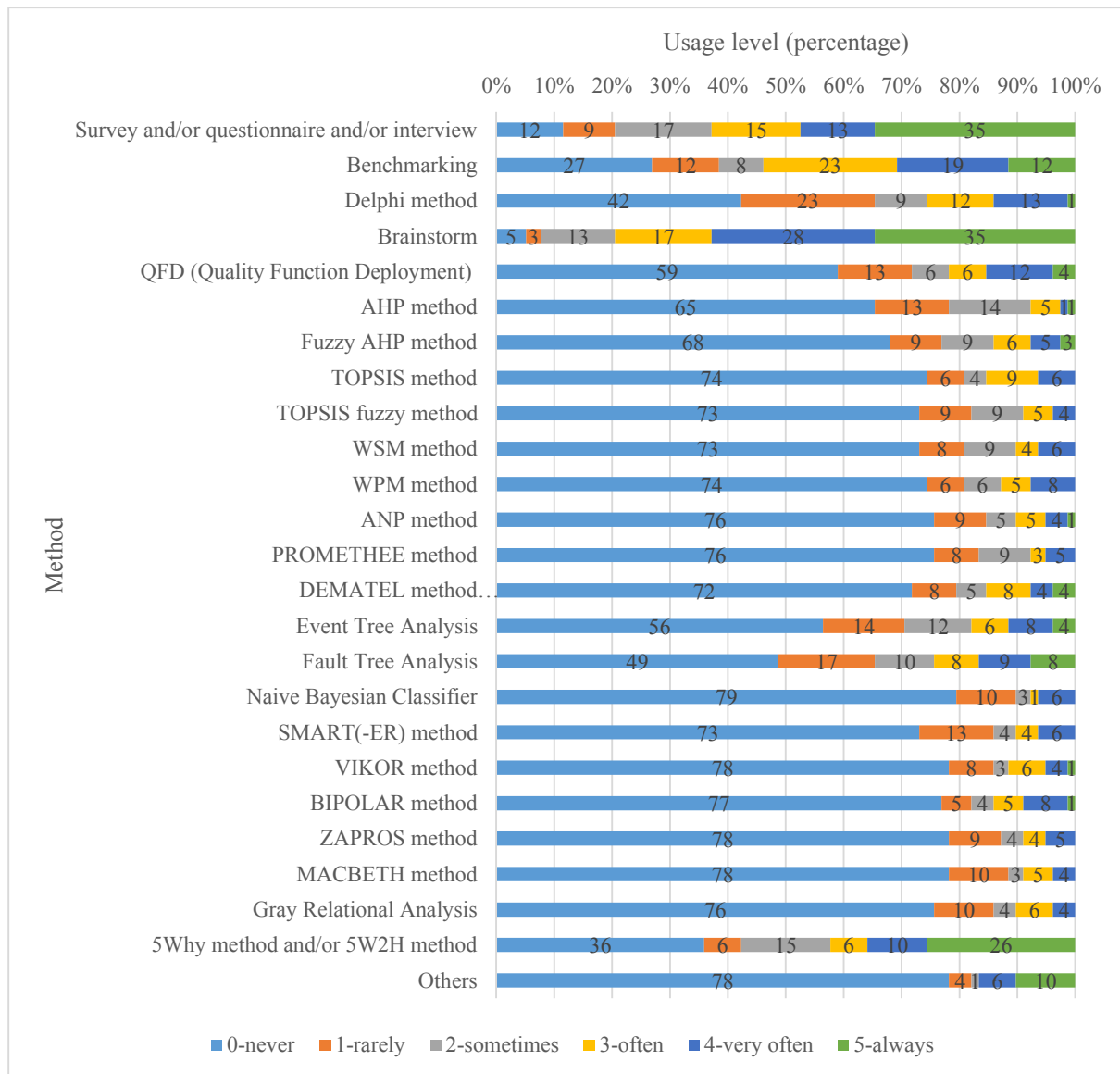


**Figure 2.** The degree of use of quality improvement methods recommended in the literature by the surveyed enterprises. Source: own study based on the results of research in enterprises. N = 78.

The remaining instruments indicated in the research were rarely used (values from 0.8 to 0.5 in the diagram). The least frequently used method was the Naive Bayes Classifier (NKB). Nearly 80% of respondents have never used instruments such as the ZAPROS method, the MACBETH method, the VIKOR method, the BIPOLAR method, the GRA method (Grey Relational Analysis), the PROMETHEE method, and the ANP method (Analytical Network Process) in decision-making processes related to the improvement of product quality. About 70% of the respondents have never used: the TOPSIS method (Preference ordering by similarity to ideal solution and fuzzy TOPIS method), SMART(ER) method, WSM method (weighted sum model), WPM method (weighted product model), DEMATEL method (Laboratory of trial and evaluation of decision making), fuzzy AHP method. The low degree of use of the methods proposed in the literature may result, among others, from the lack of knowledge about their existence and/or the deficit of various types of possibilities of their use in a given industry, in various decision-making areas, or the lack of knowledge/skills in the correct methodology of their application in practice. Further research in this area seems interesting.

The respondents were asked to indicate instruments used in decision-making processes in order to improve the quality of products and to determine the frequency of their use in decision-making processes (Figure 3).





Legend: More than one answer was possible.

**Figure 3.** Instruments used to improve the quality of products. Source: own study based on the results of research in enterprises. N = 78.

The following methods were used with varying frequency in decision-making processes: Delphi method by 58% of respondents, Tree of Failure Analysis (FTA) by 52% of respondents, Event Tree Analysis (ETA) by 44% of respondents, and the QFD method (House of Quality) by 41% respondents.

The surveyed companies that have implemented a management system based on ISO standards tend to use about 5 methods out of 25 cited in this study (these are the survey, brainstorming, 5Why and/or 5W2H method, benchmarking, and the Delphi method).

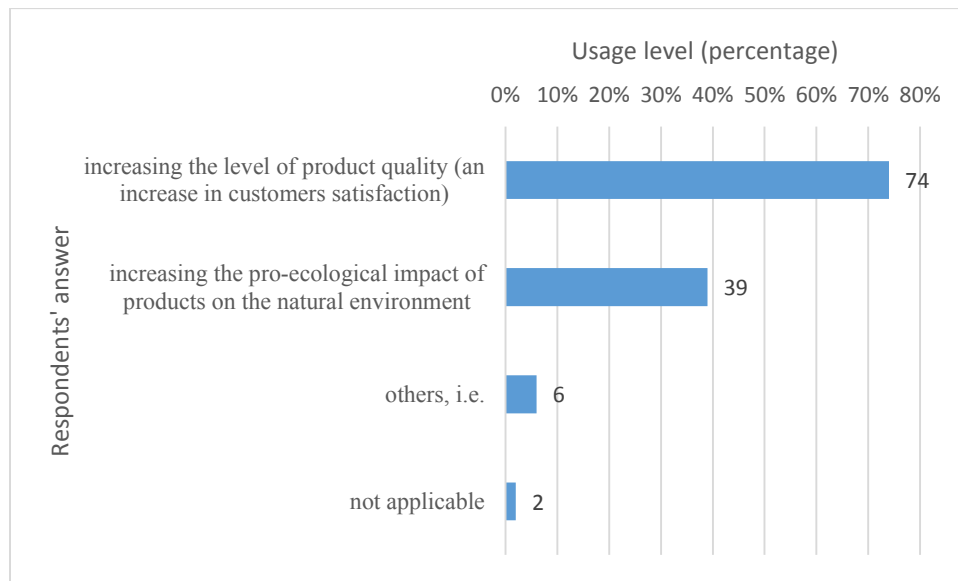
Both among companies that have implemented ISO 9001 and those that are at the stage of implementing a quality management system, there is a clear focus on the use of methods such as surveys, benchmarking, 5Why and/or the 5W2H method. The results of this research show that the implementation/functioning of an environmental management system, similarly to ISO 9001, may contribute to increasing the awareness of the existence of other quality improvement methods. As part of the continuous improvement of management systems, the best available practices are often disseminated, for example (within the supply chain).

Among the companies that do not have ISO 14001 implemented, 18% of the respondents never use the questionnaire to improve the quality of their products. 59% of companies that have implemented an environmental management system declare that they always use this type of tool. Looking at the indications of companies that declared that they have a functioning quality management system based on the ISO 9001 standard, it should be noted that 51% of the surveyed companies often or always use questionnaire forms.

The implementation of formalized management systems (both based on the requirements of ISO 14001 and 9001 standard) has a positive effect on the use of heuristic methods, e.g. 5Why or brainstorming. The functioning international management standards have a positive effect not only on increasing the awareness of the existence, but also on the practical use of such a tool as benchmarking (more on Szydoło, Kołodziejczuk, 2016).

The literature on the subject highlights the growing importance of creating and using various models of quality management instruments in the production processes of each modern enterprise (Fraś, Fraś, Fraś, 2017). It is necessary, in order to generate competitive, and at the same time innovative (also in the field of pro-ecological management) solutions, that meet the complex and multidimensional requirements of a wide range of stakeholders and, in particular, meet the expectations of each client. The literature on the subject emphasizes that the deliberate use of instruments used to improve the quality of products in terms of quality and environment, in the long period, may contribute to the improvement of the competitive position of the enterprise (Mentel, Hajduk-Stelmachowicz, 2021). It is possible thanks to the increase in the quality of products (as, inter alia, the effect of improving decision-making processes at the tactical, operational, and strategic levels). It allows for effective largo-type product quality management (not only in the entire technological chain of the production process but also in logistics (Bełch, Bełch, 2021). In addition, it allows you to reduce the number of internal shortages, and thus reduce complaints, also affecting the growth of customer orders.

The conducted questionnaire research makes it possible to indicate the application or the possibility of using decision support instruments in the product improvement process. The results are shown in Figure 4.



Legend: More than one answer was possible.

**Figure 4.** The use or possible use of decision support instruments in the process of improving the quality of products in the opinion of respondents. Source: own study based on the results of research in enterprises. N = 78.

74% of the respondents emphasized the increase in the level of product quality as a result of using the methods indicated by the respondents. On the other hand, increasing the pro-ecological impact of products on the natural environment, far fewer respondents, i.e. 39%. Analysing the literature on the subject, it can be concluded that there is a broader spectrum of possibilities of using the instruments proposed in the studies (both theoretical and practical). It is a key finding in the context of the implementation of the assumptions of sustainable development, circular economy, corporate social responsibility, systemic management (quality and pro-ecological), ethics in business, and finally the increase in satisfaction of various groups of internal and external stakeholders (constantly modifying their needs in a turbulent environment). The conclusions from the in-depth interviews clearly show that, especially in the SME sector, there is a need to increase the knowledge about the essence and actual possibilities of using the recommended instruments in a modern, multi-faceted and multi-dimensional decision-making model, in order to generate a triad of economic, environmental and social benefits not only in the short term but also in the long-term perspective. All methods and instruments should be used with the entire product life cycle in mind, and this is crucial in improving the entire decision-making process at each decision-making level.

## 5. Summary

The elaboration has a cognitive value for the development of science in the face of the challenges of the circular economy. The article allows indicating the level of knowledge and use of management instruments that can support managers in the optimized decision-making desired from the sustainable development perspective. It contributes to the understanding of the essence of a systemic, integrated, and multi-faceted approach to decision-making processes related to quality and environmental management in the area of products management.

Sustainable development is part of the new management concept, which also includes an approach to product quality management in a broader sense than before (Hajduk-Stelmachowicz, 2014; Pacana, Siwiec, Bednárová, 2020; Siwiec, Pacana, 2021). In light of the challenges of the next industrial revolution (Industry 4.0), SMEs face many challenges. Among them are those concerning making optimal decisions, both qualitative and environmental. As part of the identification of the determinants of decision-making regarding product improvement, a questionnaire survey was carried out among 78 companies. Where possible, in-depth interviews were also used. It was found that the use of various decision support instruments is aimed at increasing the level of product quality in the surveyed entities, as well as increasing the pro-ecological impact of products on the natural environment. The level of use of the available instruments is low. It may result from the lack of knowledge about them, and a deficit of knowledge about the possibilities and scope of their comprehensive use in the practice of the functioning of economic entities.

The awareness of the existence, the ability to use, and the use in production companies (selected depending on the changing needs of customers) of various instruments supporting comprehensive decision-making allow to increase the level of product quality and strengthen the pro-ecological impact of products on the natural environment.

Increasing the knowledge of the subject of consideration by managers will affect the development of their competencies, reducing the level of risk associated with making a wrong decision as a result of, for example, an information gap. It will contribute to the optimization of processes related to making multi-faceted decisions (including both quality and pro-ecological criteria) taking into account the growing and changing customer requirements. Further research is necessary to enable the application of a comprehensive and systemic qualitative and environmental approach to improving the quality of products in SMEs.

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