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THE IMPACT OF MANAGEMENT CONTROL SYSTEMS ON DECISION-MAKING QUALITY THROUGHOUT THE INNOVATION PROCESS. AN EMPIRICAL ANALYSIS*

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Abstract: Increasing competition in the present dynamic business environment pressurizes companies to innovate perpetually. The ability to establish and successfully manage a permanent innovation process depends on the quality of decisions made at its consecutive stages. At the same time, management control systems provide managers with the informational basis for decision-making. Thus, the purpose of this paper was to measure the impact of different forms of management control on decision-making quality throughout the innovation process. The analysis was based on a survey conducted amongst the representatives of 64 Polish industrial companies in the third and fourth quarters of 2019 and the first quarter of 2020. Analytical tools included principal component analysis (PCA), used to aggregate data, and multivariate multiple regression models, used to determine the relationships between variables. The findings demonstrate that the relationship between mechanistic and organic forms of management control and decision-making quality may not be analyzed in isolation from the stage of the innovation process. The direction and strength of the relationships between these variables differs at consecutive stages of the innovation process in a statistically significant way.

Keywords: controlling, decision-making quality, innovation process.

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1. Introduction

Decision-making is the focal point of management science. Each improvement introduced in a company is preceded by its decision to undertake a specific action. In this approach, decisions are the occasions where individuals and institutions achieve coherence and reduce equivocality (March, 1994). This issue seems especially important nowadays, in the context of low-quality information overflow and high--quality information scarcity. Information provision is thus crucial for decision--making. To acquire the necessary data, managers use different management control systems (MCS). Mechanistic and organic forms of control found under MCS complement each other and form a comprehensive environment for steering and controlling a company's activities in different fields. The link between MCS, which provides data, and decision-making, which exploits it, appears conceptually consistent. However, the relationship between the two notions is contextual and takes different forms depending on the setting. To date, there seems to be a research gap concerning this relationship in the context of innovation management. Innovation process management is a complex issue on its own. Here, an attempt was made to study the interplay between mechanistic and organic forms of control and the quality of decisions made throughout the innovation process. In order to do so, the study adopts a specific 7-stage representation of the innovation process, and measures decision efficiency and effectiveness at each stage. Next, the obtained results are regressed over measures of mechanistic and organic control. As a result, detailed conclusions on the studied relationship are drawn, separately for each stage of the process. Such an exhaustive decomposition is driven by the complexity of the innovation process. To the best of the author's knowledge, the paper constitutes the first attempt to link the issues of management control system and decision-making quality in the context of the innovation process.

With the theoretical background established, empirical analysis was undertaken to measure the impact of different forms of management control on the decision-making quality throughout the innovation process. The study included companies listed on the Warsaw Stock Exchange in Poland. The research protocol included 84 questions referring to both the form of management control and decision-making quality. The most important finding of the study is that organic forms of control corresponded better to the needs of the innovation process, especially in its early phases. The skillful use of mechanistic forms of control may improve the efficiency of decision-making to some extent, but generally hinders its effectiveness.

The paper is composed of four sections. First, the theoretical background is presented. Second, the methods used in the empirical study are briefly described. Third, the results are provided, and the paper ends with conclusions.

2. Theoretical background

Management control systems

Management control systems (MCS) support decision-making by providing data and information. In order to do so, MCS need to employ a set of different control forms and tools at each stage of the process. The division adopted in this study includes mechanistic and organic forms of control. The former involves formal rules, standardized operating procedures, and routines. This includes: budget control (Rockness and Shields, 1984), output and results control (Macintosh, 1994), patriarchal control – centralised control from the top (Whitley, 1999), and process controls – direct measures of the production process (Chenhall, 1997). The latter reflects the norms of cooperation and communication. This involves fewer rules and standardized procedures and tends to be richer in data (Chenhall, 2003), and includes, among others: control cultures and norms (Govindarajan and Fisher, 1990), integrative mechanisms such as meetings and task forces (Abernethy and Lillis, 1995), and product development information (Davila, 2000). Organic control is intended to remain flexible and responsive, and stimulates open communication channels and the free flow of information between project leaders and subordinates (Burns and Stalker, 1961).

In terms of the innovation process, previous evidence demonstrates that mechanistic management control supports the execution of stable routines in companies where little change happens (Burns and Stalker, 1961; Ouchi, 1979). In view of this, it appears to be of little relevance to the innovation processes characterised by a high uncertainty level (Ylinen and Gullkvist, 2014). Organic control on the other hand, due to its flexibility, seems to correspond to the needs of the innovation process, which requires a high level of adaptability in the communication and structural processes (Van de Ven, 1986). The discussion is complemented by the flow of empirical evidence suggesting a positive, indirect effect of organic control on company performance through innovativeness in exploratory projects bearing high levels of uncertainty, and a similar indirect effect of mechanistic control in exploitative projects, where the level of uncertainty is lower (Bisbe and Otley, 2004; Jansen, van den Bosch, and Volberda, 2006).

In this regard, some recent evidence suggests that the simultaneous implementation of both mechanistic and organic forms of control creates synergies beneficial from the viewpoint of the innovation process (Henri, 2006; Lewis, Welsh, Dehler, and Green, 2002; Sheremata, 2000). However, at the same time, researchers report little scientific evidence of potential indirect effects, or the effects of one form of control that depend on the level of simultaneous reliance on another form of control (Malmi and Brown, 2008).

Despite the above scientific discussion, no in-depth evidence regarding the interplay between mechanistic and organic forms of management control in the innovation process was identified. Thus this study adopts a detailed model of the innovation process, and investigates the relationship between different forms of management control and decision-making quality at its consecutive stages.

3. Decision-making quality

In business practice, managers face different alternative solutions on a daily basis. Their role often boils down to the correct selection between these alternatives. Such common situations constituted the subject of previous scientific investigations. Cooper et al. performed research on “screening decisions” and defined them as a dynamic decision process wherein new product proposals are evaluated, selected, and prioritized, and resources are allocated (2001). The ultimate goal of decision-making was further described as ensuring that the selected projects maximize benefits (value) for the company, correspond to the company’s strategy, and maintain an internal balance in terms of such parameters as project risk, type, used technologies, target markets etc. (Cooper, Edgett, and Kleinschmidt, 2001).

The difficulty of decision-making is a function of information availability. The more high-quality information there is, the more appropriate decisions may be made. High uncertainty, on the other hand, hinders the process significantly. Therefore, what appears especially challenging for managers is making a decision in the presence of information deficiencies. Previous studies established that routine decisions are made frequently, and thus historical data can be gathered for use as a guide in the decision-making process, while non-routine ones are seldom made, and thus historical data are not available (Noorani, 2010). The above considerations constitute a foundation for the analysis of decision-making quality in innovation processes. The nature of innovation processes is that they include elements that are hard to predict due to the high degree of novelty involved. This unpredictability and the lack of comparative data makes their management challenging for executives. The higher the degree of novelty, the smaller the basis for comparison, and the greater the information deficiencies (Szutowski, 2018).

The current scientific needs in the field of innovation management include a decision quality assessment method and a system of information provision. The latter requirement may be satisfied to a large extent by the management control system in place (Ylinen and Gullkvist, 2014). However, the evaluation of decision-making quality in the dynamic environment of an innovation process remains a significant challenge for both the theory and practice.

The quality of decision-making is a complex variable in itself. It is composed of two dimensions: efficiency and effectiveness. The former may be defined as the “system output divided by its input. It is a measure of how well the system converts its inputs into the desired benefit that it generates. It represents the costs associated with the desired benefit. A benefit such as survival is worth any cost. Other benefits are worth only up to a certain cost. For this reason, the goals of effectiveness and efficiency must be set together so as to maintain a rational balance between a benefit and its cost” (Noorani, 2010, p. 46). Furthermore, in the context of screening decisions, efficiency was simply defined as the ratio between inputs and outputs of a process (Charnes, Cooper, and Rhodes, 1978), and explained as yielding better output quality with a lower level of input or using fewer resources while maintaining the same output quality (Hammedi, van Riel, and Sasovova 2013). At the same time, the input of the innovation process represents the time and effort needed to reach a consensus and to make a screening decision (Baker and Albaum, 1986). Decisions that are made rapidly and ensure staff commitment may be considered efficient.

Decision-making effectiveness, on the other hand, stands for the "capacity of a system to generate an output as its intended benefit. This is the main goal of managing any system. Although it is not the only goal, its absence definitely indicates that the system was either unmanageable or mismanaged" (Noorani, 2010, p. 46). Again, in the context of screening decisions, this was defined as the extent to which the screening decision met expectations established by top management regarding outcome quality in terms of the optimization of resource allocation and the strategic fit of the innovation project (Hammedi, Van Riel, and Sasovova, 2013). The idea was also simply explained as the relationship between "outputs and objectives" (Anthony and Govindarajan, 2001, p. 111). Negligence in the field of decision-making effectiveness exposes companies to two types of potential errors (van Riel, Semeijn, Hammedi, and Henseler, 2011): (1) type I errors, which occur when the company's scarce resources are spent on "failures" (De Brentani, 2000); (2) type II errors, which occur when potentially successful ideas are overlooked (Baker and Albaum, 1986).

In relation to the theoretical considerations presented above, it is hypothesised that the implementation of management controls systems may improve the decision-making quality throughout the innovation process. The link is presented in Figure 1.

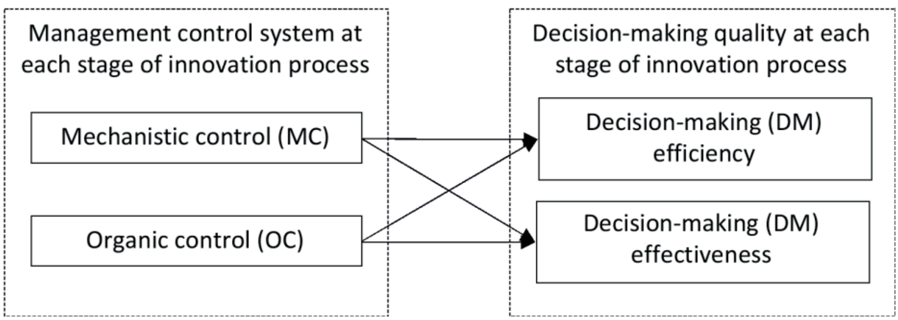

Fig. 1. The impact of different forms of management control on decision-making quality throughout the innovation process

Source: own elaboration.

Importantly, the relation between the implementation of mechanistic and organic control systems and the efficiency and effectiveness of decision-making should be considered separately at each stage of the process. Here, the assumption is made that different combinations of these types of MCS are needed to support decision-making at each stage of the process. Therefore, the next sub-chapter presents the innovation process decomposed into single stages.

4. Innovation process

Previous scientific evidence reports numerous product innovation development process models. The scientific debate in the field has continued since the 1950s. Each consecutive decade was characterized by a different dominant logic (Hobday, 2005; Kotsemir and Meissner, 2013). The last two decades focus on the openness of the actions undertaken. In the first decade of the new millennium, open innovation was the central issue. In the next, open innovator became the subject of principal interest. The difference between the two approaches is that the former focuses on innovation collaboration and multiple exploitation paths, and the latter focuses on the individual and on the framework conditions under which one becomes innovative. Innovation process models of the new generation face new requirements. They need to be flexible in order to allow companies to proactively manage customer needs and market trends (Louw, Schutte, Seidel, and Imser, 2018). The quantitative approach is now firmly supported by qualitative studies.

The decade between 2010 and 2020 was especially prolific, as a dozen or so representations of the innovation process were reported in scientific literature (Szutowski, Szulczewska-Remi, and Ratajczak, 2019). Different process models were systematically summarized in a previous literature review. In this study, the representation developed by Szutowski (2019) was adopted. It presents the model at company level, which means that individual innovation projects are all contained in it. The model is shown in a graphic form in Figure 2.

The representation is composed of seven main stages and five complementary ones. The former are coloured grey, and the latter are represented by white boxes. The numbers in the white boxes indicate the go/no-go points. The ones in the solid

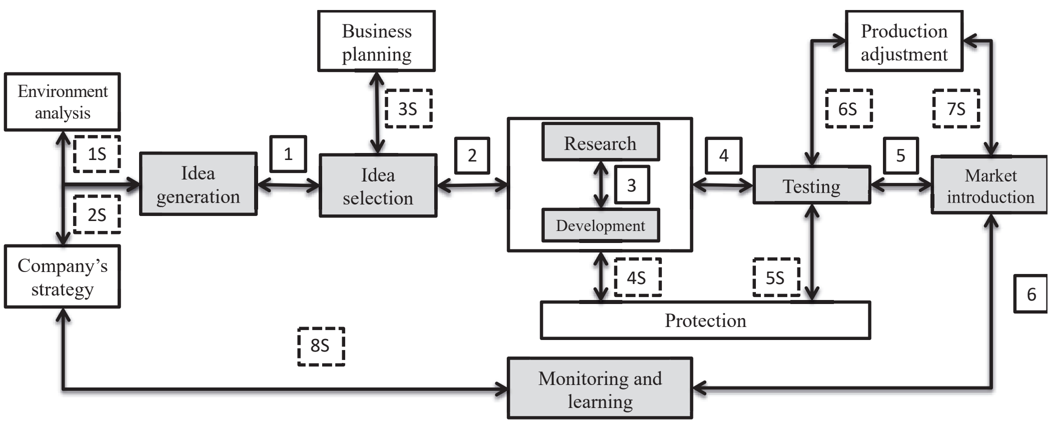

Fig. 2. Innovation process model

Source: (Szutowski, 2019).

boxes separate the main stages of the process. The numbers suffixed with "S" and shown in dotted boxes represent the supplementary go/no-go points. The two-sided arrows indicate that all the stages are mutually linked. The flow of the process may continue from earlier to later stages, but feedback loops drawing the process back from later stages to prior ones are also possible. Due to the subject of the study and the above representation, the quality of decision-making needs to be measured at least seven times throughout the process. The impact of different management control system forms may vary at each stage.

What is important here is that the model is constructed at company level, not single project level. This means that members of different functional areas of the company undertake their activities within the stages at the same time. Despite the logical flow of the process leading from the early stages, e.g. idea generation, to later ones, such as market introduction, the process should not be seen as sequential, but rather as a representation of different functional areas that are linked in order to achieve innovation. The functional areas all operate at the same time (idea selection happens year-round, R&D is performed year-round, etc.). As far as individual projects are concerned, the model guarantees flexibility. Not all projects need to pass through all the stages, the stages may overlap, and activities may be moved from one stage to another, etc. Moreover, there is no strict link between the model and different departments within a company. It is assumed that they may all contribute at different stages.

5. Research methods

The purpose of the study was to measure the relationship between the form of management control and the decision-making quality within the innovation process. In accordance with the literature, the latter was represented by a composite measure comprising efficiency and effectiveness. Management control systems, on the other hand, were divided by the form of control into mechanistic and organic. Due to the adopted representation of innovation process, both measures were evaluated seven times (at all the main stages of the process).

The empirical, quantitative investigation was conducted in the third and fourth quarters of 2019 and in the first quarter of 2020. The subjects of analysis were companies listed on the main market of the Warsaw Stock Exchange and the NewConnect market (the alternative trading system operated by the Warsaw Stock Exchange). Therefore, the population included 838 companies, and was studied as a whole, with no sampling procedure in place. Data were gathered for 107 companies (response rate 12.77%); however, due to missing data, only 64 companies were analyzed (7.64% of the population). A strict approach to case selection was adopted, whereby a single missing value eliminated the case from analysis. Consequently, due to the sample size, the results may not be generalized for the entire population.

The respondents represented senior management, management, CFOs, innovation managers, and project leaders. If necessary, more than one respondent was questioned to gather the data. The research protocol consisted of 84 questions. Most entities in the final set were industrial companies (73%), and other types, such as service (17%), trade (5%), and agricultural (5%) enterprises were less commonly represented. The single most represented sector was life science and medicine, which accounted for 22% of the population.

All the information was collected by a specialized data collection agency with the use of the computer-assigned telephone interviewing survey technique. The questionnaire was specially developed for the study. Seven-point rating scales were used, ranging from 1, "strongly disagree", to 7, "strongly agree". The respondents were asked to deliver their views based on the last five years' experience of their companies. In most cases, this time frame included the period of 2015 to 2019 or 2020.

The "decision-making quality" section consisted of five items. Each respondent provided a total of 35 answers in this section (5 items x 7 stages). Two items referred to decision-making efficiency, and the remaining three to decision-making effectiveness. Next, the "management control" section consisted of seven items. Therefore, a total of 49 answers were given by each respondent (7 items x 7 stages). Before the main study, the questionnaire was extensively tested in a three-step preliminary study. In order to test the internal consistency of each group of questions, Cronbach's alpha was calculated. The results indicated a high level of internal consistency within all the four groups specified: decision-making efficiency (0.85), decision-making effectiveness (0.63), organic form of management control systems (0.79), and mechanistic form of management control systems (0.72). The research protocol is presented in the Appendix.

In the data analysis process, two main statistical tools were used. First, principal component analysis was employed seven times to aggregate data on decision-making efficiency and the effectiveness at each stage of the process. Second, multivariate multiple regression (MMR) was performed seven times to study the relevant relationships at each stage of the process.

Principal component analysis (PCA) allows for representing a set of variables by a smaller number of variables called principal components. PCA may be used for ordinal data, although it is principally designed for interval data (Cornish, 2007). To estimate factor score coefficients, the PCA procedure relies on regression. Therefore, for each stage of the innovation process, first the items concerning decision-making efficiency (the workload used, and decision-making speed) were aggregated to form a single new variable representing efficiency. Then the items related to decision-making effectiveness (consistency with the company strategy, keeping with available financial resources, contribution to overall company performance) were aggregated to produce a single measure of effectiveness. The scores were standardized, so they have a mean equaling zero and a variance equal to the squared multiple correlation between the estimated factor scores and the true factor values. The standardized values constituted the input variables for multivariate multiple regression. In order to determine the sampling adequacy of data the Kaiser--Meyer-Olkin (KMO) test was performed for both the efficiency and effectiveness of decision-making, followed by Bartlett's test of sphericity. The results were satisfactory, with the KMO's test values matching consecutively: 0.782 (0.03) and 0.683 (0.04).

Thus, at each stage of the process, there were two dependent variables – decision--making efficiency and decision-making effectiveness. Hence, multivariate multiple regression was necessary. By definition, this constitutes a method of modelling multiple dependent variables using a single set of predictors (Johnson and Wichern, 2007). During the procedure, each dependent variable is regressed separately on the predictors. In other words, MMR is "multiple" because there is more than one independent variable (here, there are 7 at each stage, and 49 in total), and "multivariate" because there is more than one dependent variable (here, there are 2 at each stage, and 14 in total) (Datallo, 2013).

6. Results and discussion

The analysis produced a total of 15 results considered significant at p-values of 0.01 and 0.05, and indicative at the *p*-value of 0.1. Eight of these were positive, and the remaining seven were negative. Despite such balanced results, some regularities seem to emerge once the variables are decomposed into detailed measures of decision-making quality (efficiency and effectiveness) and management control form (mechanistic and organic). The whole set of data is presented in Table 2. The positive results are coloured light grey and negative are dark grey. The bold lines separate four distinctive sections, representing from the top: decision-making efficiency and organic MCS, decision-making efficiency and mechanistic MCS, decision-making effectiveness and organic MCS, and decision-making effectiveness and mechanistic MCS.

It appears that the organic form of control employed within the management control system corresponds better to the needs of innovation processes than the mechanistic one. For both decision-making efficiency and effectiveness, the employment of organic control produced positive results in four cases, and a negative value only once. What is even more visible is the concentration of positive results at the early stages of the process. More specifically, the organic form of control improved decision-making efficiency at the idea generation stage and decision--making effectiveness at idea generation, idea selection, and research stages. In light of the above results, in order to maintain a high quality of decision-making, managers should support informal ways of solving process performance issues and encourage open channels of communication and the free flow of information between staff.

Table 1. Parameter estimates

	Stage	IG	IS	R	D	T	MI	ML
Efficiency	intercept	–0.513	–0.138	0.337	–0.343	–0.015	–0.555	0.624
	face	–0.033	0.137	0.04	–0.042	–0.002	–0.087	–0.095
	informal	–0.079	–0.068	0.031	–0.063	–0.007	0.078	0.053
	channels	0.193*	–0.035	–0.019	0.119	–0.037	0.002	–0.193*
	rules	0.038	0.028	–0.291*	0.068	0.142+	0.02	–0.107
	targets	–0.104	–0.051	0.213+	0.014	0.037	0.182+	0.288*
	deviations	–0.042	–0.028	0.032	–0.021	–0.152+	0.055	0.006
	report	0.119	0.016	–0.051	–0.018	0.01	–0.134	–0.067
Effectiveness	Intercept	–0.724	–0.03	–0.221	0.256	–0.242	1.321*	0.155
	face	–0.105	0.002	0.03	0.111	0.016	–0.031	–0.005
	informal	0.078	0.016	0.131+	–0.06	0.093	–0.064	0.007
	channels	0.147+	0.156+	0.029	0.082	–0.031	0.126	–0.063
	rules	0.049	0.01	–0.258*	0.101	0.014	0.003	0.003
	targets	–0.108	–0.196+	–0.038	–0.292**	–0.051	–0.274*	–0.116
	deviations	–0.029	0.104	0.152	0.03	–0.058	0.091	0.043
	report	0.121	–0.081	0.047	–0.023	0.087	–0.106	0.107

** – $p < 0.01$; * – $p < 0,05$; + – $p < 0.1$; IG – idea generation, IS – idea selection, R – research, D – development, T – testing, MI – market introduction, ML – monitoring and learning.

Source: own elaboration.

The interpretation of the findings concerning mechanistic control in the MCS requires a breakdown into decision-making efficiency and effectiveness, as the results produced in these cases differ from each other. The general conclusion seems to be that the mechanistic form of control decreases decision-making effectiveness within the innovation process. The use of formal rules, regulations, and procedures, and a focus on specific line-by-line process performance targets creates a strict managerial framework that seems ill-suited to the requirements of an innovation process. While the observation does not necessarily represent a universal principle, it appears to hold firmly in the case of the innovation process, where four negative parameters were reported in the idea selection, research, development, and market introduction stages.

The employment of mechanistic control produced mixed results in terms of impact on decision-making efficiency. At the research and testing stages, no clear conclusion may be formulated because of the combination of positive and negative parameters. At the market introduction and monitoring and learning stages, specific line-by-line process performance targets supported the efficiency of decision-making.

7. Conclusion

The purpose of this study was to measure the impact of different forms of management control on decision-making quality throughout the innovation process. An empirical, quantitative investigation was performed, which included companies listed on the main market of the Warsaw Stock Exchange and the NewConnect market. The respondents representing senior management, management, CFOs, innovation managers, and project leaders answered a series of 84 questions concerning forms of management control and decision quality at the seven stages of the innovation process. The results indicate that organic forms of control corresponded better to the needs of an innovation process, especially in its early stages. The skillful use of mechanistic control may improve the efficiency of decision-making to some extent, but generally hinders its effectiveness.

Following further quantitative and qualitative studies expanding the results, a managerial tool useful for steering innovation processes may ultimately be developed. At this stage of the research, however, the results may be used only as a context-specific guideline. The study adopted the spatial scope of Poland, therefore expanding it to cover a wide range of European economies seems a worthwhile direction for further research. Moreover, a specific analysis of the tools (a diversified set of financial and non-financial tools) employed in both forms of management control appears necessary for both theory and business practice. Furthermore, the measurement of the impact of decision-making quality on innovation process efficiency seems warranted.

Based on the empirical study, all the objectives of the study were met to a large extent. However, the study was not free of limitations. First, due to the sample size, the results may not be generalized for the entire population. Second, the protocol was extensive, and completion of the questionnaire was time-consuming, which resulted in missing data found in 40% of the responses gathered. Strict control over the data gathering process in further research is necessary.

Appendix

The items used in the research were evaluated at each stage of the process separately, meaning that each item was evaluated seven times. The items are presented below.

Two items concerning decision-making efficiency:

- The workload used to make a decision is optimal (not too much and not too little research, consultations etc.).
- The decisions at this stage are made rapidly.

Three items concerning decision-making effectiveness:

- The decisions at this stage are consistent with the company strategy.

- The decisions at this stage are made in accordance with the available financial resources.
- The decisions at this stage contribute to overall company performance.

Three items concerning the organic form of management control systems:

- The staff involved are called to discuss process performance deviations in face-to-face meetings.
- The staff involved often informally discuss and resolve process performance issues together.
- The manager in charge encourages open channels of communication and the free flow of information between staff.

Four items concerning the mechanistic form of management control systems:

- The process is organized based on formal rules, regulations, and procedures.
- Interest is taken not only in overall, but also specific line-by-line process performance targets.
- A great deal of importance is attached to temporary deviations from the performance targets.
- Actions taken to correct deviations from the performance targets must be reported.

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WPŁYW CONTROLLINGU NA JAKOŚĆ DECYZJI PODEJMOWANYCH W PROCESIE INNOWACYJNYM. ANALIZA EMPIRYCZNA

Streszczenie: Współczesna rzeczywistość gospodarcza charakteryzuje się nasilającą się walką konkurencyjną, która wymusza na przedsiębiorstwach podejmowanie ciągłych działań innowacyjnych. Możliwość ustanowienia nieprzerwanego procesu innowacyjnego uzależniona jest od jakości decyzji podejmowanych na jego kolejnych etapach. Jednocześnie systemy controllingowe dostarczają menedżerom informacji niezbędnych do podejmowania decyzji. W tym kontekście celem niniejszego artykułu było zmierzenie wpływu implementacji różnych typów controllingu na jakość decyzji podejmowanych w ramach procesu innowacyjnego. Analizę empiryczną oparto na badaniu ankietowym przeprowadzonym wśród przedstawicieli 64 polskich przedsiębiorstw giełdowych w trzecim i czwartym kwartale 2019 roku oraz pierwszym kwartale roku 2020. Dane zagregowano przy wykorzystaniu analizy głównych składowych (PCA), a kierunek i siłę zależności pomiędzy zmiennymi określono z użyciem regresji wielorakiej. Uzyskane wyniki wskazują, iż zależność pomiędzy wprowadzeniem organicznych i mechanistycznych typów controllingu a jakością decyzji nie może być analizowana w oderwaniu od etapu procesu innowacyjnego. Kierunek i siła zależności pomiędzy tymi zmiennymi różni się w sposób statystycznie istotny na kolejnych etapach tego procesu.

Słowa kluczowe: controlling, jakość decyzji, proces innowacyjny.