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FINANCIAL CHALLENGES IN PRODUCTION ENGINEERING USING KEY PERFORMANCE INDICATORS – A CASE OF DIFFERENT PRODUCTION PROCESS TYPES

5.1 INTRODUCTION

In the era of development of knowledge-based economies, materials used and other direct costs play an increasingly smaller part on the overall product production cost. At the same time, the share and significance of indirect costs, including the use of non-material resources of production companies and expenditures on obtaining and processing information about the manufacturing process, increase. The changes in the structure of production costs in turn affect the demand for financial services, which can utilise methods of cost calculation [2] and management while at the same time tackling previously unseen issues which need to be addressed individually and creatively. Gathering information on the costs incurred and their proper use in the decision-making process holds key significance from the point of view of production process engineering, also in small companies [9]. Moreover, special attention should be paid to the use of computer technologies which enable us to carry out complicated and multi-variant calculations, but do not answer the question of the accuracy with which figures obtained through such calculations reflect the economic reality.

The aim of the article is to showcase a set of key performance indicators (KPI) useful in the process of operational management of the main financial areas of a production process [8]. The authors, by presenting the example of a small company providing varied services, wish to state their conviction about the necessity of taking into account not only financial, but also non-financial parameters which shape production processes, including data in non-monetary units. The key performance indicators, designed using non-financial discriminants, are helpful in making decisions pertaining to the planning, designing and controlling production processes in the case of varied production and/or services.

5.2 CONNECTION OF CONTROLLING AND PRODUCTION PROCESS ENGINEERING

Improvement of the productivity indicator, understood as the relation between effects and expenditures made to obtain them, is an important goal in the operation of modern companies [7]. Apart from increasing sales, a way to increase productivity is reducing production expenditures, which is not possible without a proper information base created by the managerial accounting departments, including controlling specialists. The products of controlling are analyses, budgets, indicator calculation results, simulations and feasibility studies [12] pertaining to, among others, data necessary for managing costs which determine productivity. Therefore, the controlling departments deal not only with the ex post analysis of the production projects being conducted, but also equally support the current decision-making processes [14] and are engaged in making prognoses, modelling processes and projects. The accumulation of tasks is especially visible in small companies, where one position combines many tasks and functions. Because production engineering encompasses, among others, the issues of work time (employees and means of production) management and material and information flow [7], the objective of controlling is to support the process analysis and provide information on the flow of materials, information as well as human and financial resources. The above results in a necessity of creating complex models illustrating the functioning of production processes, which make it possible to, e.g. study the influence of individual factors on characteristics such as productivity [11].

A complement to the specially designed management reports aimed at supporting production processes is reporting resulting from the accounting records kept by companies. Especially valuable from the perspective of managers responsible for controlling the production processes are analytical reports of operational costs by cost nature, entity [4] or taking into account the reaction of costs to the changes in the type of products manufactured (or services provided). Another valued tool is financial analysis aimed at assessing the efficiency of resources used and analysing the profitability of individual types (segments) of activity or the accepted uniform group of services provided (goods manufactured).

The recipients of reports created by controlling specialists are the employees of the unit, especially the managers responsible for preparing production, organising production processes and managing manufacturing processes. Information created in controlling departments is, therefore, a closely guarded trade secret, which can determine the company's competitive advantage. From this perspective, managerial accounting, including controlling, plays an important role in achieving the company's objectives and is an integral part of the company managing process, including the management of production processes. Due to the above, information created in controlling departments are often available only for selected employees who require them as a basis for decision-making. A controlling department employee, especially in small units, has the knowledge on the entirety of information they create, which, on

one hand, puts them under a great deal of responsibility [13], while on the other being crucial to accurately reflecting the production processes using selected models or key performance indicators.

5.3 KEY PERFORMANCE INDICATORS AS PRODUCTION ENGINEERING TOOLS

Creating reports for the purpose of productiveness management should rely primarily on financial data, i.e. the description of economic reality using a monetary measure. The above approach is consistent with the description of accounting, whose system encompasses controlling. The basic function of accounting is providing information for the purposes such as company management. However, on the other hand, because the issues of production engineering encompass many systems that function simultaneously in a company (which, among others, integrate employees, information or processes over the products' entire life cycles), focus on the human factor, which actively shapes these systems, is necessary in order for controlling to fulfil the informational function. Moreover, cost management for the optimisation of production processes and, as a consequence, an increase in productiveness, cannot do without encompassing work time management, production order scheduling, ergonomic design or information flow.

Designing key performance indicators should begin with identifying the company's strategic goals, operational objectives from the area of manufacturing processes connected with them, as well as critical success factors. Critical success factors are, naturally, situational [5], however, among example goals and success factors connected with them we can enumerate increasing product quality, which can be assessed using a desired level of technical parameters of the provided services (or goods produced). Increasing employees' efficiency, on the other hand, can be verified by measuring the degree of completion of the assigned tasks or with calibrated scoring techniques. The subject literature [12] indicates that every critical success factor should be connected with at least one final success factor, but at the same time the limit of three key performance indicators per every critical success factor should not be exceeded. The next stage of designing key performance indicators consists in defining information created by controlling, determined by the division of responsibilities in the company. The above means that reporting within controlling is determined by the connections between the company and its surrounding, and should furthermore take into account relations with a wide range of stakeholders, including employees of various levels, suppliers and clients. This stage of designing key performance indicators ultimately crystalizes critical success factors and places responsibility for them on individual organisational units or particular positions. From the characteristic of the key performance indicator design stage we can infer that, on one hand, KPIs must reflect the needs of managers at various levels of production process management, on the other,, they result from the managerial structure of the company, but at the same time are also dependent on the importance of the area of operation under assessment (or the product manufactured/service

provided) to the functioning of the company as a whole [6]. This also means that key performance indicators should also be considered at different levels of production process management, as it is necessary to divide the entire company's success factors between lower levels of management [1, 3], including events which make up the process of manufacturing (or providing a service). The authors believe that a breakdown of indicators is needed also in small companies, especially in the case where varied services are provided.

The possibility of integrating the key performance indicators into the already existing IT managerial reporting system is also not without significance to the set of indicators being created. The applicability of the key performance indicators designed to the already existing IT tools is significant for conducting modelling and computer simulations which are important from the perspective of process design, production task scheduling and restructuring the already existing production system. The above constitute a weighty element of the managers' decisions and actions, also in terms of utilising new business models which shape new organisational solutions in the company and, therefore, in the production processes. The possibility of conducting a computer simulation based on ex post key performance indicators also facilitates adapting to the organisational changes planned as a result of the managing staff's decisions. Another plausible scenario is one where significant changes may need to be introduced to the already existing IT tools in response to the key performance indicators designed. If key performance indicators are designed mainly in order to organise priorities and determine operational objectives with which the company's strategy will be realised, it seems inappropriate not to use KPIs with regard to adapting the IT system [10]. The complete use of key performance indicators may need to be spread out over time, forgoing their implementation, however, appears to be the worst possible solution from the perspective of providing information for the purposes of multi-dimensional production process management.

5.4 PROPOSAL OF KEY PERFORMANCE INDICATORS FOR THE PURPOSES OF PRODUCTION ENGINEERING OF VARIED PRODUCTS

Subject literature indicating exemplary key performance indicators, also those designed with the characteristic of small companies in mind, presents many possibilities largely relying on financial data. The subject of this work are KPIs encompassing non-financial data, as they allow for a broader assessment of efficiency and profitability. Subject literature offers slight hints in terms of designing KPIs in small companies, which are aimed at monitoring and controlling production processes (providing services).

The authors believe that in the case of a small company providing varied services, it is necessary to distinguish several areas in which KPIs should be designed:

- occupational health and safety,
- equipment maintenance,
- the production process, taking into account efficiency and innovativeness,

- quality,
- and other areas depending on the specific nature of the company's activity (e.g. environmental protection requirements).

In the next stage, in each of the areas it should be checked whether it is possible and justified to disaggregate data into individual varied production processes, i.e. whether the KPIs designed will be decided for the individual types of products (services) or the subject of assessment will be production as a whole. It is also important to define the frequency with which KPIs are produced as this in turn determines the cyclical nature of efficiency and profitability assessment of the production processes. While KPIs based on financial data are usually produced monthly, performance indicators using non-financial data can be used in different time intervals

As the aim of the article is to bring attention to the importance of including non-financial measures, the set of indicators shown in Table 5.1 has been reduced to only include indicators which incorporate non-financial information. Key performance indicators based solely on financial data (such as cost structure, share of expenditures in income or cost dynamic), while also important to the decisions made as part of production process management, were omitted in the present elaboration. The authors aimed for the article to present non-financial parameters, including non-monetary data, which are helpful in designing key performance indicators for managing the production processes of a small company.

All the indicators presented in Table 5.1 can be used for data determined for the entire company (whole production) as well as selected products (services) or defined uniform areas of activity. Taking into account the aim of the article, we should assume that KPIs reflect the provision of specific services (production of products) with varied characteristics and their focus on measuring key processes as opposed to all the processes present in the company. The above means a necessity of gathering certain information about the operation of machines and people broken down by the various types of services (products) distinguished. On the other hand, these data make it possible to differentiate varied services (products) or distinct assortments.

Moreover, an important issue is the allocation of indirect costs, which notably include maintenance of machines and equipment, health and safety, energy and heating of the production space. Decisions pertaining to the allocation of the aforementioned costs shape the production cost of individual assortments of products (services). For this reason the authors suggest that the set of data being the basis for decision-making (including cost optimisation) should be expanded with non-financial data which are not characterised by indirect cost allocation choices. The share of indirect costs in the overall manufacturing cost is significantly higher in modern companies, which is why the production cost of a product (expressed in monetary units, regardless of the calculation method) cannot be the base piece of data used for decision-making in production engineering.

Table 5.1 Selected key performance indicators for production process management in a small company with varied production (service provision)

Key performance indicator	Indicator description
Time lost due to accidents (dangers, undesirable events)	$\frac{\text{Working time lost due to accidents}}{\text{total working time}}$
Accident frequency	$\frac{\text{Number of accidents}}{\text{number of man} - \text{hours worked}}$
Accident seriousness	$\frac{\text{Number of hours absent due to accidents}}{\text{number of accidents}}$
Machinery stoppage time	$\frac{\text{Machine repair time}}{\text{total nominal machine working time}}$
Average repair time	$\frac{\text{Time of stoppage due to breakdowns}}{\text{number of failures}}$
Machine use	$\frac{\text{Machine working time}}{\text{Total nominal machine working time}}$
Quality	$\frac{\text{Production output} - \text{faults}}{\text{production output}}$
Work time use	$\frac{\text{Hours worked}}{\text{hours present}} \times 100$
Employee engagement in returns	$\frac{\text{Number of man} - \text{hours spent on correcting faults (returns)}}{\text{Number of returns}}$
Employee efficiency	$\frac{\text{Added value of completed production}}{\text{number of man} - \text{hours of employees directly engaged in production}}$
Machine efficiency	$\frac{\text{Completed production value}}{\text{machine working time}}$
Resource use	$\frac{\text{Planned working time (employees/machines)}}{\text{Nominal (total) working time}}$
Losses (waste) in the production process	$\frac{\text{Amount of resources lost (wastes), waste mass}}{\text{Amount of resources input to production}}$
Average time of the product manufacturing (service provision) process	$\frac{\text{Actual completion time of the manufacturing process}}{\text{number of completed product (service) orders}}$
Deviation of actual production process duration from the plan	$\frac{\text{Actual} - \text{planned duration of the production process}}{\text{planned duration of the production process}} \times 100$

5.5 CONCLUSION

Properly designed key performance indicators identify the gap between expectations and actual performance, which constitutes a key piece of information for the managers dealing with production process control. Among the proposed indicators are measures which initiate the production process, which allow for the assessment of available resources from the organisational, machinery and human perspective and can therefore be the basis for making decisions about the company's ability to fulfil the already made or planned obligations toward the clients. Among the example indicators showcased in the article are also indirect indicators, which are helpful in assessing the fulfilment of production requirements, e.g. by providing information about deviations from the planned production process. Finally, among the recommended indicators are final indicators used for the assessment of production process realisation.

The simultaneous use of key performance indicators based on financial and non-financial measures eliminates the weak points of financial indicators (focus on direct costs, ignoring quantitative data, low sensitivity to the changes in company strategy) and highlights the importance of time and process indicators. Thereby, the

risk of overlooking some critical aspects of production processes such as flexibility, quality or use of internal resources decreases. Moreover, the key performance indicators proposed make it possible to assess the creation of added value, which often determines the competitive advantage of small companies. For this reason, the above non-financial data should be taken into account by managers responsible for managing production processes when making decisions.

REFERENCES

1. M.A. Abernethy. "Budget use, task uncertainty, system goal orientation and subunit performance: a test of the 'fit' hypothesis in non-for-profit hospitals." *Accounting, Organizations and Society,* no. 16(2), 1991, pp. 105-120.
2. J.A. Brierly, Ch.J. Cowton. C. Drury. "Research into product costing practice: a European perspective." *European Accounting Review*, no. 10(2), 2001, pp. 215-256.
3. J.A. Comesana-Benavides, J.C. Prado-Prado. "Implementing key performance indicators in small and medium-sized enterprises through personnel participation, A case study." *Dirrecion y Organizacion*, no. 48, 2012, pp. 17-22.
4. C. Drury, M. Tayles. "Product costing in UK manufacturing organizations." *European Accounting Review*, no. 3(3), 1994, pp. 443-470.
5. J. Gerdin. "The impact of departamental interdependencies and management accounting system use on subunit performance." *European Accounting Review,* no. 14(2), 2005, pp. 297-327.
6. S.G. Green, M.A. Welsh, N.R. Baker. "Dependence. Uncertainty, and the control of subunit performance." *Accademy of Management*, August, 1987, pp. 165-169.
7. *Istota inżynierii produkcji*. Komitet Inżynierii Produkcji Polska Akademia Nauk, 2012.
8. S. Kaganski, A. Snatkin, M. Paavel, K. Karjust. "Selecting the right KPIs for SMEs production with the support of PMS and PLM." *International Journal of Research in Social Sciences*, no. 3(1), pp. 69-76.
9. M. Nastasiea, C. Mironeasa. "Key performance indicators in small and medium sized enterprises, TEHNOMUS Conference Proceedings. *New technologies and products in machine manufacturing technologies*, 2016, pp.46-53.
10. A.I. NicolauI. "Manufacturing strategy implementation and cost management systems effectiveness." *European Accounting Review,* 2003, no. 12(1), pp. 175-199.
11. A. Niemiec. *System pomiaru dokonań w przedsiębiorstwach*, Warszawa: CeDeWu, 2016.
12. B. Nita. *Sprawozdawczość zarządcza. Analizy i raporty wewnętrzne controllingu,* Warszawa: PWN, 2014.
13. M. Nowak. „Etyka controllingowego pomiaru dokonań w świetle filozofii utylitarystycznej – zarys koncepcji." Zeszyty *Teoretyczne Rachunkowości*, no. 82(138), 2015, pp. 113-128.
14. A. Sulik-Górecka. „Analiza rentowności klientów z wykorzystaniem rachunku kosztów działań jako narzędzia controllingu strategicznego,"[w:] *Zarządzanie kosztami przedsiębiorstwa w warunkach ryzyka. Aspekty teoretyczne,* Wydawnictwo Wydziału Zarządzania Politechniki Częstochowskiej, 2014, s. 127-134.

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FINANCIAL CHALLENGES IN PRODUCTION ENGINEERING USING KEY PERFORMANCE INDICATORS – A CASE OF DIFFERENT PRODUCTION PROCESS TYPES

Abstract: *The article investigates the management of production processes in case of differentiated manufacturing processes that occur in a small enterprise. Authors state that appropriate managerial decision-making should encompass non-financial indicators of important costing determinants that are crucial for cost management and their improvement. The aim of the article is to develop a possible set of key performance indicators helpful in achieving operational objectives in main performance areas. By incorporating non-financial (and non-monetary) data referring to production activities, authors indicated important determinants that should be included into effectiveness and economics evaluation carried out within production engineering.*

Key words: *production engineering, cost management, KPI, cost allocation*

ASPEKTY FINANSOWE WYKORZYSTANIA KLUCZOWYCH MIERNIKÓW DOKONAŃ W INŻYNIERII PRODUKCJI – PRZYPADEK JEDNOSTKI ŚWIADCZĄCEJ NIEJEDNORODNE USŁUGI

Streszczenie: *W artykule poruszono problem zarządzania procesami wytwórczymi w sytuacji braku powtarzalności działań produkcyjnych, tj. świadczenia niejednorodnych usług. Autorzy stwierdzają, że właściwe podejmowanie decyzji wymaga uwzględnienia parametrów niefinansowych, które kształtują koszty produkcji i są kluczowe w procesie zarządzania kosztami. Celem artykułu jest wskazanie zestawu kluczowych mierników dokonań użytecznych w procesie operacyjnego zarządzania głównymi finansowymi obszarami procesu produkcyjnego. Poprzez włączenie niefinansowych (i niepieniężnych) danych o działalności produkcyjnej (usługowej) wskazano na istotne determinanty procesów wytwórczych, które powinny mieć znaczenie dla oceny ich efektywności i ekonomiczności wyrażanych tradycyjnie za pomocą informacji finansowych.*

Słowa kluczowe: *inżynieria produkcji, zarządzanie kosztami, kluczowe mierniki dokonań, KPI*