Key Indicators of the Production Process in Global Environment

Žaneta Rylková[1,*], *Šárka* Čemerková[1] , and *Pavla* Pokorná[1]

[1]Silesian University in Opava, SBA Karvina, Department of Business Economics and Management, Univerzitní nám. 1934/3, 733 40 Karvina, Czech Republic

Abstract.

Research background: Globalization brings rapidly changing global environment and highly competitive environment which manufacturing companies force to fight not only for their place in the market, but also to use various management methods and, above all, measure and manage their business performance. In production companies, the basis for performance measurement and management is to monitor data from production process, which should help to obtain an up-to-date production overview and serves a basis for planning processes, and remuneration of employees or for evaluating the efficiency of resources and equipment.
Purpose of the article: Many approaches and indicators companies use for this evaluation, including key performance indicators. The aim of the article is to design key indicators for the evaluation of production process and to create a model for reporting the results from the production process.
Methods: The design of the production process evaluation has been creating on the analysis and evaluation of the primary survey and according to the methodologies of production process steps for the determination of key indicators from available secondary sources. The contribution brings the primary data collection of a recent survey conducted in manufacturing companies in the Czech Republic.
Findings & Value added: The paper sets up internal evaluation indicators for businesses using the elementary principle based on evaluation of the Overall Equipment Effectiveness.

Keywords: *manufacturing companies; business performance; evaluation; Overall Equipment Effectiveness*

JEL Classification: *L20; L23; M11*

* Corresponding author: rylkova@opf.slu.cz

1 Introduction

Global environment and organizational adaptation are ubiquitous in management research and act as the glue binding together the central issues of organizational change, performance, and survival [8, 12]. Organizational adaptation operates at three distinct levels of analysis (internal, market, and institutional) and that these levels interact with each other. Internal adaptation represents the degree to which organizations align their resources, competencies, structures, goals and measurement of business performance [1, 12, 13].

Manufacturing companies should focus the production process on achieving the optimal functioning of systems in production with regard to the set goals, and above all it is a matter of material, spatial and temporal harmonization, or coordination of resources involved in production processes. The objectives of production management should be based on the objectives set out in the company's strategy, and for the area of production management, two basic objectives are usually derived: maximum satisfaction of customer needs and efficient use of available production resources. Production management includes several activities from the assignment of planned tasks to production, through the management of material supply, coordination of operations and registration of the production process to the identification of abnormalities and the organization of their correction.

Production indicators are important for the development of manufacturing companies, as they describe the parameters on the basis of which we can evaluate companies and later effectively manage them. The most important production indicators include measuring productivity, overall equipment effectiveness (OEE), production capacity, time funds. Production indicators appear in complex models for measuring company performance, such as the Balanced Scorecard method.

The aim of the paper is to introduce key production indicators of production process within a model reporting the production process based on the secondary and primary research. Due to productions activities complexity, it is possible to work in manufacturing companies with an efficient tool that allows to measure production efficiency and to conduct production more effectively.

2 Theoretical background

While business performance measurement is essential for many production operations, accuracy of measurements has impact on validity and usefulness of performance metrics developed for evaluation, planning, and improvement of production processes [14]. The techniques for measuring the performance of a Smart Manufacturing facility are like those in regular use at most production factories: Key Performance Indicators (KPIs). The major differences are the number of stakeholder types responsible for achieving the KPI targets, and the breadth of available technologies they can apply in the process. Given the level of automation in today's leading semiconductor manufacturing plants, the most important tools these stakeholders have are the manufacturing applications that provide data analysis, decision support, production scheduling, process monitoring and control, yield management, and a host of other capabilities necessary for running a profitable enterprise in a hyper-competitive global environment [17].

Business environment demands an instant replay to different influences that appear in the production process and in the global market. The synthesis of plant-wide control structures is recognized as one of the most important production-management design problems in the process industries. To develop a production control system, in appropriate model of the production process is needed to evaluate the various control strategies. Within the model different production Key Performance Indicators (KPIs) can be identified which are used to extract the relevant information about the state of the production process [4].

Production is determined based on three characteristic key performance indicators (KPIs): Productivity, Mean product quality and Mean production costs. These KPIs are used to control the process of production [4].

The risks related to overuse, nonuse and misuse of indicators are analyzed from the perspectives of indicator contents, processes of production and communication and external context factors. Opportunities for avoiding different risks and improving the desired societal impacts and influences of indicator usage are discussed. The concept of risk is helpful in terms of empirical diagnosis and for formulating mitigation recommendations [7].

Production lines' performance measurement is a vital activity that aids production operations as well as making managerial decisions at different hierarchical levels. For instance, an effective way to support productivity improvements is to utilize performance measures [14]. The value of information on production process helps to build up a new evaluation model for production process evaluation that closely corresponds to a reverse production chain for recovery and utilization to making the product manufacturing much efficient and the overall efficiency of business entities. The objective measure of manufacturing enterprises is the overall equipment effectiveness (OEE) indicator of production facility within the production process, which has been creating for the analysis and evaluation of the production processes of the manufacturing enterprises [11]. The overall equipment effectiveness indicator of production facility measures the relation between the real production of identical products $(Q_{REAL\ QUAL})$ and the planned production volume (identical products), $(Q_{PLAN\ QUAL})$ [11].

The decomposition of the OEE indicator follows [11]:

$$OEE = (Q_{REAL\ QUAL}/Q_{REAL}) * (T_{P\ REAL}/T_{P\ PLAN}) * (V_{REAL}/V_{PLAN}) \quad (1)$$

Quality indicator C_{QUAL} — Time utilization indicator C_{EXT} — Output utilization indicator C_{INT}

The quality indicator evaluates the proportion of real produced identical products to the planned quantity. As part of the planning mechanism, an assumption is, that only identical (quality) products are produced during the production process at time known as the productive time fund ($T_{P\ PLAN}$). The time utilization indicator of production capacity assesses the relation between the real productive time fund $(T_{P\ REAL})$ and the planned productive time fund $(T_{P\ PLAN})$. The output utilization indicator of production capacity evaluates the ratio between the real reported output of the assessed production facility (V_{REAL}) and its projected (planned) value (V_{PLAN}) [11].

Gupta and Garg [5] implemented total productive maintenance (TPM) to improve OEE of an automobile manufacturing organization. The authors developed a database for further use and handled the data. Tsarouhas [16] investigated the relationship between the management and the operation of a production line, where the OEE metric is used to plan the maintenance strategy of machines. Nonetheless, these studies did not consider measurement errors causing inaccuracies in the components of OEE, but intrinsically assumed that the measurements are accurate. Sun et al. [15] implemented and evaluated TPM in a manufacturing company, where mean time between failures as a performance indicator was measured. Zammori [18] also considered uncertainty, risks in production environments and calculated OEE using fuzzy numbers.

Borovska *et al*. [2] discuss the task of optimizing manufacturing systems, waste recycling, based on the methodology of optimal aggregation. Production process model that theoretically relates production loss with line speed and stoppage duration of a continuous production line have been developing. This model can be used to calculate the production loss given the line speed and the line's stoppage duration over a period of time [3, 9, 11, 14].

3 Methodology

The primary research took the form of a questionnaire survey and was focused on the use of performance indicators in manufacturing companies in the Czech Republic. Data were collected in 2019. The objectives of the quantitative part of the research in a selected group of companies in the Czech Republic can be summarized as follows: describe the current state of use of performance indicators, analyze the attitude of companies to measure and manage performance. The final sample consisted of 67 manufacturing companies out of 140 companies, which were included among the "Pike of Czech business" in the year 2018. With regard to the nature of the researched issues, cooperation was established with employees in managerial positions who evaluate and manage the financial position and performance of the company or the entrusted area (general directors, financial, production, economic directors). The questionnaires were structured into several sections, where one section of the questionnaire was focused on information concerning the use of specific measures, tools, methods and concepts for measuring and managing the production process and the company's attitude to value management. The primary research questionnaire was compiled on the basis of a literature search, previous knowledge and experience, and last but not least, discussions with employees of manufacturing companies. Five companies were asked to study the questionnaire and answer questions in order to remove inaccurate wording, ambiguities and errors.

4 Results

Performance in the analyzed companies is evaluated mainly on the basis of results from financial statements - balance sheet, profit and loss statement and cash flow, and in addition they use key performance indicators (KPIs), especially from a financial perspective. The main indicators that companies monitor for their needs include sales, operating profit, EBITDA, value added per employee, gross margin, inventory turnover, receivables turnover, ready liquidity and number of employees.

In the area of production, companies do not focus on evaluating the production cycle efficiency and the overall equipment efficiency, but they monitor the indicator of production capacity and its utilization. However, regular reports are not performed on these indicators. The key indicators monitored in production include the following indicators in selected companies (Table 1).

All surveyed companies calculate material consumption, energy consumption, the number of hours of downtime, production capacity and time fund of production equipment. 37 % of asked companies are not planning to calculate coefficient of total production capacity utilization.

Table 1. Indicators monitored in production.

Indicator	Yes, we measure the indicator	No, we are planning to implement	No, we are not planning to implement	No, we do not use, we do not know the indicator
Material consumption	100 %			
Number of completed products	55 %	45 %		
Share of delayed deliveries to total deliveries	73 %	27 %		
Inventory turnover	79 %	21 %		
Energy consumption	100 %			
Labour productivity	84 %	16 %		
Adherence to the production schedule	72 %		28 %	
Frequency of equipment failures	77 %	23 %		
Number of hours of downtime	100 %			
Production capacity	100 %			
Production delays	77 %	23 %		
Time fund of production equipment	100 %			
Coefficient of total production capacity utilization	63 %	37 %		
Overall equipment efficiency	1 %			99 %
Production cycle efficiency	1 %			99 %
Research and development costs	18 %	29 %	53 %	
Shipping costs	85 %	15 %		
Complaint costs	74 %	26 %		
Average age of production program	7 %		93 %	
Delivery time	73 %	27 %		
Product profitability	58 %	42 %		
Number of deliveries sent on time	60 %	40 %		
Quality indicator	1 %			99 %
Time utilization indicator	1 %			99 %
Output utilization indicator	1 %			99 %

Coefficient of total production capacity utilization belongs to the most important factors of company economics. The indicator measures the relation between unused and used (real) production capacity. The non-utilization of production capacities has influence on the decrease of the efficiency of the expended fixed costs, as a result of their degression [6].

It is interesting that from 67 companies only 39 companies analyze product profitability when this analysis helps to identify the most and least profitable existing products and customers, moreover it solves issues that can affect profit margins and provides essential knowledge to adjust products mix in order to maximize profitability.

5 Discussion

Only 1 company measures overall equipment efficiency from the 67. The value of the indicator overall equipment efficiency in the conditions of large companies is around 85%. However, the recommended value for production managers, which companies in the OEE should at least approach, can be set at 75%. The production cycle efficiency measure is designed to measure the duration of either the entire production process or its individual activities. By processing time is meant here the time when the product is actually worked on and the transit time also includes other activities performed from inspection to storage. Its ideal value is to get as close as possible to 100%, which, however, is usually impossible to achieve, so it is advisable to try to get closer to it.

Production process measurements play an important role in the total business performance implementations through OEE calculations. In these, OEE metric is dependent on stoppage duration, speed of production, and nonconforming production through production loss measurements [10, 14].

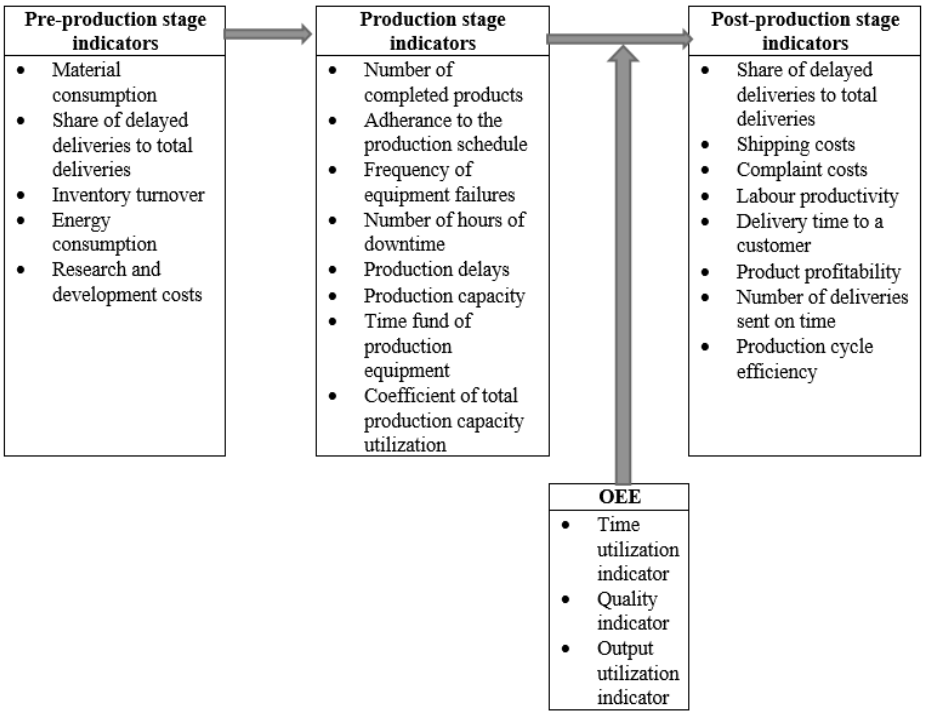

Fig. 1. Model for reporting the results from the production process

In the literature, most business performance metrics do not consider production process measurements. However, measurement of production process due to various factors and in different forms are not uncommon in businesses. In this study, a manual production measurement system is considered within production lines and measurements are formulated through secondary and primary research by considering physical conditions of continuous manufacturing systems of analyzed companies.

Our model, see figure 1, Model for reporting the results from the production process, documents mechanisms of indicators explaining which production process measures can be used into account of business performance metrics and can positively affect business development: by 1) Pre-production stage indicators, 2) Production stage indicators, 3) Overall equipment efficiency (OEE), and 4) Post-production stage indicators. We propose that these four mechanisms can identify causally relevant attributes and measures of business performance and allow us to conceptually distinguish strategic business performance management and measurement system in our future research.

6 Conclusion

Due to the complexity of production activities, it is possible to work in production companies with an efficient tool that allows you to measure production efficiency and perform production more efficiently and with quality, and allows all support services and processes to be precisely managed. This article shows a model for reporting the results of the production process, captures the quality system defined together between production and quality assurance. The model can be a powerful tool and should provide information in the production unit to control the production process and valuable data to manage the performance of the production company as a whole. This paper is an output of the science project of the Silesian University in Opava SGS 6/2018 “Economic Literacy of Business Entities”.

References

1. Baumann, O., Eggers, J.P., Stieglitz, N. (2019). Colleagues and Competitors : How Internal Social Comparisons Shape Organizational Search and Adaptation. *Administrative Science Quarterly,* 64(2), 275-309.
2. Borovska, T. N. (2014a). Optimal aggregation of production systems with parametric connections. *Eastern-European Journal of Enterprise Technologies*, 4(11(70)), 9–19.
3. Iannone, R., Nenni, M.E. (2013). Managing OEE to optimize factory performance. In : *INTECH* (pp. A33-A36). Croatia : Open Access Publisher.
4. Gradisar, D., Zorzut, S., Jovan, V. (2008). Model-based Production Control. *Automatika*, 49(3-4), 151-158.
5. Gupta, A.K., Garg, R.K. (2012) OEE improvement by TPMimplementation: a case study. *International Journal of IT, Engineering and Applied Sciences Research*, 1(1), 115–124.
6. Kutac, J., Janovska, K., Samolejova, A., Besta, P., Vilamova, S., Voznakova, I. (2013). The Impact of Production Capacity Utilization on Metallurgical Companies Financing. *METABK*, 52(1), 135-137.
7. Lyytimäki, J., Salo, H. Lepenies, R., Büttner, L., Mustajoki, J. (2020). Risks of producing and using indicators of sustainable development goals. *Sustainable development*, Early Access.

8. Marshall, V.B., Brouthers, L.E., Keig, D.L. (2020). RIMS : A new approach to measuring firm internationalization. *Journal of International Business Studies*, 51, 1133-1141.
9. Muchiri, P., Pintelon, L. (2008). Performance measurement using overal equipment effectiveness (OEE): literature review and practical application discussion. *International Journal of Production Research*, 46(13), 3517–3535.
10. Parida, A., Kumar, U., Galar, D., Stenström, C. (2015). Performance measurement and management formaintenance: a literature review. *Journal of Quality in Maintenance Engineering*, 21(1), 2–33.
11. Rylkova, Z., Stelmach, K., Vlcek, P. (2018). Overall Equipment Effectiveness Within Counterfactual Impact Evaluation Concept. *Scientific Annals of Economics and Business*, 64(SI), 29-40.
12. Sarta, A., Durand, R., Vergne, JP (2020). Organizational Adaptation. *Journal of Management,* 24, 1011-1025.
13. Siggelkow, N. (2002). Evolution toward Fit. *Administrative Science Quarterly*, 47(1), 125-159.
14. Sonmez, V., Testik, M.C. (2017). Using accurately measured production amounts to obtain calibration curve corrections of production line speed and stoppage duration consisting of measurement errors. *International Journal of Advanced Manufacturing Technology*, 88(9-12), 3257-3263.
15. Sun, H., Yam, R., Wai-Keung, N.G. (2003). The implementation and evaluation of total productive maintenance (TPM)—an action case study in a Hong Kong manufacturing company. *International Journal of Advanced Manufacturing Technology,* 22(3–4), 224–228.
16. Tsarouhas, P.H. (2013). Equipment performance evaluation in a production plant of traditional Italian cheese. *International Journal of Production Research*, 51(19), 5897–5907.
17. Weber, A. (2018). Smart Manufacturing Stakeholders and Their Requirements. In : *e-Manufacturing and Design Collaboration Symposium* (pp. 1-3). Taiwan : IEEE.
18. Zammori, F. (2015). Fuzzy overall equipment effectiveness (FOEE): capturing performance fluctuations through LR fuzzy numbers. *Production Planning & Control*, 26(6), 451–466.