University of Economics in Katowice

Journal of Economics and Management

e-ISSN 2719-9975 ISSN 1732-1948 Vol. 43 • 2021

sciendo

Ireneusz P. Rutkowski

https://orcid.org/0000-0002-3821-3533

Department of Market Research and Services Management
Institute of Marketing
Poznań University of Economics and Business,
Poznań, Poland
Ireneusz.Rutkowski@ue.poznan.pl

Competence measurement of production enterprises in product innovations for technological and marketing strategies

Accepted by Editor Ewa Ziemba | Received: October 28, 2020 | Revised: January 24, 2021; February 15, 2021 | Accepted: March 4, 2021 | Published: March 17, 2021.

Abstract

Aim/purpose – This paper attempts to arrange and present the methods of measuring the competences of production enterprises in the field of product innovations.
Design/methodology/approach – The method used in this paper is a literature review, in the area of new product development management. The author assumes that the review and conceptual nature of this research is dominant.
Findings – The obtained results indicate the importance of measurement in product innovation competencies and provide various metrics in this field. The author proposes new indicators to measure competencies in this area, i.e., the intensity of competition on new products market.
Research implications/limitations – The results provide a basis for improving efforts of production enterprises in the field of product innovations. The limitations of the study include a complex character of considered theoretical constructs. Sets of measures must be adapted to the information needs of a specific enterprise.
Originality/value/contribution – The values of these indicators reflect the directions of industrial enterprises' conduct in the process of developing new products and technologies. Moreover, these indicators show the strength of linking technology with the effectiveness of new product development, and consequently with the enterprise marketing, economic and financial efficiency. The contribution of research to the development of management sciences primarily includes the formulation of a set of indicators whose level determines product innovation competencies in industrial companies.

Cite as: Rutkowski, I. P. (2021). Competence measurement of production enterprises in product innovations for technological and marketing strategies. *Journal of Economics & Management, 43*, 110-130. https://doi.org/10.22367/jem.2021.43.06

Keywords: competence measurement, product innovation, production enterprise, new product, technical and marketing strategy.
JEL Classification: O31, O32, M21.

1. Introduction

The enterprise competencies in the field of innovative activity can be assessed at different levels (macro, meso, micro), and in various sectors of the economy. This evaluation requires the use of appropriate measurement methods (Juchniewicz & Grzybowska, 2010, p. 11). In particular, resolving the problem of measuring innovation at micro level is necessary in the efficient management of an organization, it requires availability of analytical tools that enable measurement (Hervas-Oliver, Sempere-Ripoll, Boronat-Moll, & Rojas-Alvarado, 2018; Wodecka-Hyjek, 2013). Measurement of business activity efficiency level has been an important element of planning and control in the management process for many years (Khosravi, Newton, & Rezvani, 2019).

The effectiveness of control of the new product strategy and new product development process will depend on the adequacy of measures used. In the historical perspective, the most frequently and widely used are financial measures, on the basis of which companies conduct management monitoring of organizational efficiency (Carboni & Russu, 2018; Reinertsen & Smith, 2001). However, financial measures alone do not provide full information on efficiency of company's operations. Revenues, profits and other financial measures can be subject to numerous manipulations (reducing expenditure on research and development, training, marketing, falsification and concealing information). The significant problem is what happens over time, when the effects of these 'savings' reveal a drop in competitiveness, a drop in profits, a loss of growth dynamics and a decrease in the level of success of new products introduced to the market, a decrease in confidence in the company (Rutkowski, 2007).

Although research and development is a key indicator of technological innovation, scientists have found mixed results regarding its effect on product innovations and enterprise performance. Researchers claim that variations in R&D effectiveness can be explained by changes in a firm's social system, in particular in its management innovation. It is still unclear how innovation management influences R&D effectiveness in terms of product innovation process (Heij, Volberda, Van den Bosch, & Hollen, 2020).

The scientific aim of the paper is an attempt to arrange and present methods of measuring the competencies of production enterprises in the field of product innovation. The purpose of the paper is to determine what metrics/indicators can

be used by these companies to measure product innovation competencies. The author assumes that the paper conveys a review and conceptual nature of this research. Methods and indicators of production enterprise competencies in the field of product innovations in the context of technological and marketing strategies were identified on the basis of the literature review and opinions of scientists and experts representing management sciences. The research provides various indicators at the class and method level.

This paper includes the following sections: literature review, research methodology, research findings. In the research findings section of the paper, measures of technological competitiveness and innovativeness of manufacturing enterprises are analyzed. The next section contains the discussion. The paper ends with conclusions.

2. Literature review

The literature review indicates that research on efficiency measures in the field of product innovation process focuses on complex aspects of success and failure of new products and on strategic aspects, the nature of relationships between company's efficiency, its intellectual capital and management (Blindenbach-Driessen, van Dalen, & Ende, 2010; Griffin & Page, 1996; Kristiansen & Ritala, 2018; Smith, 2005).

Hoffmann (1999) noted three main positions on the definition of competencies. One of these defines competencies as an observable performance whose focus is the result or task to be completed; therefore, particular performances are described as competencies and taken as a basis for the assessment, observation, and measurement of a person's performance. Second, competencies are considered a quality standard of outcomes of person's performance, in which competencies are associated with the achievement of productivity gains or efficiency in the workplace. Thus, competencies here are defined within context of organizational performance objectives or standards. Third, competencies are defined as a person's inherent attributes, i.e., knowledge, skills, and attitudes for competent performances. Although the first two are focused on result that the person produces, the last focuses on individual input that is required to perform competently (Hisrich & Kearney, 2012; Jajja, Kannan, Brah, & Hassan, 2017).

The studies conducted so far indicate that the implementation of product innovation strategy should be undertaken with particular care in a company in order to ensure appropriate coordination, integration and communication link

with the existing processes and to achieve the goals, for which this strategy is implemented (Engelman, Fracasso, Schmidt, & Zen, 2017). This statement suggests that it is necessary to evolve the structure of a new product development process in accordance with the direction of the organization's development, continuously supporting strategic changes and the company's growth goals (Barczak, 1995; Cooper & Edgett, 2003; Krawiec, 2000; Neely, 1998).

Effective strategic management also requires the use of measures other than financial ones. That is why an increasing number of companies around the world measure customer loyalty, employee satisfaction, brand evaluation and value, competence development, and other non-financial aspects of the company's operations. The problem is that many companies fail to link these measures to strategic goals or to establish the relationship between the actions taken and the results achieved (Magnier-Watanabe & Benton, 2017). The consequences are wrong decisions and waste of funds on programs – projects that do not contribute to the improvement of the company's results and its market position. Research showed that different companies make similar mistakes (Cooper, 2017).

Table 1 presents some selected goals of a new product development strategy, which are of a different financial, marketing (market) and technological nature, and they provide detailed criteria, in a sense that they significantly determine the overall success of a new product on the market. However, the level of success of a new product on the market should be taken as a general measure of a manufacturing company's competence in the field of product innovations, in particular the effectiveness of new product development strategies. Table 1 contains both measures of competencies in achieving specific goals in the product innovation process (House––Price model) and measures related to the level of achieving goals of new products after period of commercialization and introduction of new products to the market.

Table 1. Strategic goals of new product development

Goals of the product innovation process – (level of experience and competence)
Specific performance indicators for the new product (e.g., uptime, energy consumption).
Unit production cost.
Time to market TTM – total time spent on development, from the initial stage of development to the start of production.
Time for research and development TRD – time and cost of the research stage until the start of the development stage.
Break-even after start of production BEAR – the time from the start of production until the investment costs are covered by product returns.
Break-even time BET – the time from the initiation of the research to the moment when the profits from the product equate with the investment made on the given project.
Return factor, return of investment RF or ROI – the result of dividing the sum of profit by the sum of investments after commercialization of a new product

Table 1 cont.

Goals of the new product after the commercialization period
Normal break-even point BEP.
Equilibrium capital threshold – time when present value of sales of a new product covers present value of total expenses.
The threshold for raising capital – moment when a new product generates a financial surplus that allows for reinvestments that extend the life cycle or support development of other products.
Net present value – NPV.
Internal Rate of Return – IRR.
Sales of a new product (e.g., during the first 12 months).
The level of profit from the sale of a new product (e.g., during the first 12 months).
Market share of the new product (e.g., during the first 12 months of sale)

Source: Based on: House, Price (1991); Kirsner (2015).

The success of a new product can be measured at two levels: at the project-program portfolio level and at the level of individual new product concepts included in a project portfolio. Therefore, depending on the level of measurement, measures used for this measurement will also differ. For example, measures of financial success are important when assessing a portfolio of projects – programs, while the importance of such measures decreases when assessing individual projects. However, a major problem in determining success of individual outputs is the multidimensionality of new product development results (Rutkowski, 2016).

Previous studies have indicated that the success of a new product is determined by the following independent dimensions of factors: related to the recipient of marketing offer, of financial nature, related to efficiency of process and technological competences. It should also be borne in mind that each of these dimensions may also contribute to the failure of a new product. Especially, a low level of process efficiency and technological competences may significantly affect the failure of a new product. Hence, companies often have to sacrifice a certain level of success in a given dimension to achieve greater success in another. Thus, with the knowledge currently available, there is no perfect new product development process, as evidenced by the long-standing relatively high failure or partial failure rate of a new product on the market (Castellion & Markham, 2013).

A significant outstanding problem is the time taken to measure success of a new product. Enterprises differently define the time during which a product is considered new by them. Generally, this time span is from 1 to 5 years. However, the author in this paper assumes the maximum period of one year, during which a specific product can be considered as new by manufacturer. Nevertheless, when measuring the level of success, relativity of time must be taken into

account. Measurement of the technological efficiency of a new product is important in the short term, while the measurement of satisfaction or financial revenue level is relatively important in a long term. Here, too, you need to take into account the projected life cycle time of a product.

3. Research methodology

Measuring methods and indicators of competences of production enterprises in the field of product innovations, in the context of technological and marketing strategies, have been identified on the basis of a literature review, the research contained therein of scientists and experts representing management science, in particular in the area of new product development. Thus, the author used the following research method: systematic review – a type of literature review focusing on one topic, based on scientific evidence. The scientific study is also based on already conducted and published other empirical studies and the author refers to these works in the paper. Therefore, the paper uses theoretical research methods, such as teleological and functional explanations, source analysis and criticism.

4. Research findings

Basically, the measures of competence in implementation of a new product development strategy, which are used by manufacturing companies, are reactive in nature, i.e., they show an ex post, past situation. The following problems are associated with this approach: analytical inertia, unclean play, abuse of report results, dividing employees. However, reactive measures have their value and should be used in the company, also to control the process of new product development and its market success. Strongly, reactive measures are supported by predictive measures that allow enterprises to predict the course of certain phenomena in the future. It is the predictive measures that should be the key competence indicators in the product innovation process. G. D. Githens (2002) pointed to four model design parameters for these measures: efficiency, performance, signal/noise, power of influence. These dimensions enable the identification of opportunities to create predictive metrics to understand the procedure and system design measures[1].

[1] Efficiency is an operationally oriented measure of productivity, performance is the ability to achieve the intended results, signal/noise is a measure of ambiguity, it presents the relation between the amount of data generated in a formalized process and the amount of information (designing a system of measures requires that to decide whether to prefer a high signal/noise

When assessing a new product strategy, the most useful financial measure is the profit level set for a given project. Among classic marketing measures, measures of the level of satisfaction and acceptance of the offer by recipients, as well as the market share index, are characterized by relatively high usability. Nevertheless, a useful measure reflecting the efficiency of the process and technological competencies is the technological competitive advantage and efficiency of the product.

The measure of technological competitive advantage in this system is intrinsic and reflects the level of technological efficiency of a new product and its specific properties, and at the same time is not clearly defined. For example, for a manufacturer of washing machines, important parameters of technological efficiency will be the level of water consumption, energy, washing and spinning efficiency, while for a manufacturer of emulsion paints, durability of the color and coverage of the painted surface, toxicity, etc.

Table 2 presents a set of measures defining the level of competence and abilities of project teams in the field of product innovations. The presented set of measures did not distinguish categories (measures based on costs, sales and profits, project development time, quality, staff work, communication level).

Table 2. The quantitative indicators to assess the competence and ability of project teams in new products development

Average sales of a new product per one person involved in the development process
Average profits from a new product per person involved in the development process
Average production of a new product per one person involved in the development process
Average number of prototypes built per new product placed on the market
% of projects moved to the next phase after the first assessment
% implementation level of the Research and Development plan
% R&D plan excess
% decrease/increase of the Research and Development budget
% of investments allocated to the development of a new product
% of investments allocated to maintaining existing products
% change in allocation ratios of staff involved in the product development process, e.g., engineering and design team/marketing team
The average number of new product projects implemented per one person involved in the process of their development
Number of selected ideas for a new product (in quarter, year)
% of ideas accepted from selected ideas

or high influence strength), quantitative measures usually have a high signal/noise ratio, e.g., ROI, profit, production, project cost index, the strength of influence shows the commitment of limited resources to achieve the desired efficiency. However, an example is the measurement of imbalances in individual market segments, this is measure of the strength of influence are predictive.

Table 2 cont.

Number of projects of a new product under development (in quarter, year)
% of new product prototypes accepted (in quarter, year)
Number of accepted prototypes, but shelved (in quarter, year)
Number of prototypes in subsequent phases of the development process (in quarter, year)
Project development time, actual project completion date compared to the planned one
% of the volume of current turnover generated by the sale of new products in the last *n*-years
% of the current turnover in relation to the value of technology licenses
Sales of new products in the first year
Sales of new products after two years
Sales of new products after three years
Sales of new products after four years
Sales of new products after five years
% of the volume of current profits generated by the sale of new products in the last *n*-years
% of current profits in relation to the value of technology licenses
Profit from new products in the first year
Profit from new products after two years
Profit from new products after three years
Profit from new products after four years
Profit from new products after five years
Number of patents registered
Number of patents filed per one person involved in the development process
Number of industry standards achieved
Number of granted/acquired licenses
Value of obtained subsidies for the development of a new product
Research and development expenditure as % of sales value
Average development costs for one new product design
Average capital costs involved in product development

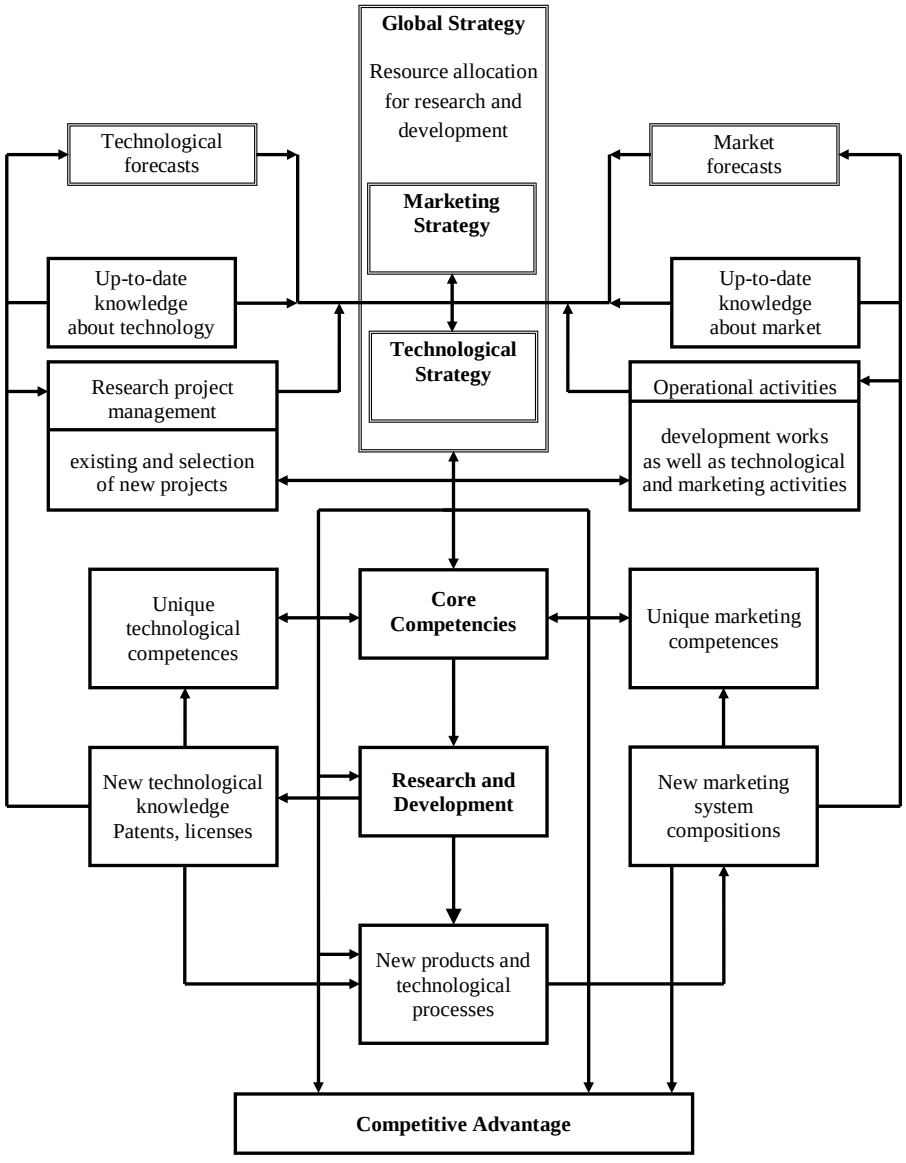
Source: Based on: Rutkowski (2007, 2016).

The technological strategy is part of company's overall strategy and consists in selection of future technical systems (e.g., databases, laboratories, industrial installations, production lines), technological processes and products. It must take into account marketing orientation and new concept of goodwill (Kasprzak & Pelc, 1999, 2012). However, in the last decade, we have witnessed the development of a new company paradigm, which assumes that the resources of marketing, organizational and technological knowledge are of central importance for the value of company. This new way of thinking makes it necessary to formulate a technological strategy at three levels in the field of:

– shaping the company's competencies, reflecting technological knowledge resources,
– research and development, being the sources of knowledge and new technological solutions for products and processes,
– mastering technological processes and product manufacturing systems as tools of competition.

Kasprzak & Pelc (2012) stated that above three levels of technological strategy formulation, require prognostic recognition and strategic analysis of a different nature. The general procedure of company's technological and marketing strategy analysis is shown in Figure 1.

Figure 1. Areas of strategic analysis in the decision-making process of formulating technological and marketing strategy



Source: Author's own elaboration.

Large industrial companies prepare technological and market forecasts using their own sources of information or commission specialist consulting companies to obtain forecasting information. Institutional sources of medium- and long-term forecasts are government agencies, professional associations, and university centers. Forecast information provides the basis for the process of preparing research initiatives. Forecast analysis is a form of communication about emerging and future technologies, expectations, preferences and priorities. Nevertheless, small and medium-sized industrial enterprises do not usually go beyond the horizon of two years in their technological and market analyzes, although they can flexibly react to changes in the area of technology and market, content with current review of technological novelties and market trends.

In the area of technological strategy, core competencies reflect the well--established technological knowledge resources at the disposal of the company, necessary for its efficient functioning, and at the same time determine the possibility of establishing strategic units. The level of core technological and market competences is usually assessed by a given company. However, it should be remembered that a change in their scope and intensity results in the necessity to acquire and spend significant resources. Unique technological expertise and marketing concern specific aptitudes and talents of employees with narrow specialization, inventions and methods of operation and experience accumulated in the practice. These competencies make it possible to distinguish the company in the competitive environment, and at the same time determine the level of market success. Therefore, there is a need to constantly monitor internal innovation processes and the situation in the marketing environment, using proposed indicators, to undertake new product projects with a high probability of success in the future.

4.1. Measures of technological competitiveness

The process of coordinating technological and marketing strategy is one of important conditions for decision to allocate resources between various research and development projects. This process also requires an assessment of effects of resources involved, and therefore the problem of measuring these effects arises. The results of a technological strategy can be assessed on the basis of technological achievements and their impact on the results of company's marketing activities, especially in terms of revenues from sale of new products or capital expenditure (Taques, Lopez, Basso, & Areal, 2020).

In the scientific publications, as well as in statistical sources (Commission Regulation (EC) No. 1450/2004 of 13 August 2004), among many indicators used to compare and determine the change trends in technological strategies of various industries and companies, the following measures of industrial enterprises' competence in area of product innovation and intellectual property protection are particularly useful (OECD/Eurostat, 2018; Grzegorczyk & Głowiński, 2020):

- innovative activity intensity (IAI), research, and development intensity (RDI), new products marketing intensity (NPMI);
- engagement to innovation (IE), research and development (RDE) and marketing of new products (NPME) – the degree of development of intellectual resources in relation to production investments;
- new product sales index – marketing product offer renewal (NPS);
- patent activity index (PAI);
- inventive activity index (IAI).

The above quantitative indicators can be the basis for analysis of technological potential and innovative strength of enterprises. The values of these indicators also reflect the directions of industrial enterprises' conduct in the process of developing new products and technologies, as well as in other areas of innovative activity (processes, management, organization, sales and marketing). Moreover, these indicators show the strength of linking technology with effectiveness of new product development, and consequently with the marketing and financial efficiency of enterprises.

The intensity of innovative activity, including research and development and marketing of new products, is defined as a percentage ratio of expenditure on innovation, research and development activity and marketing of new and modernized products to the total value of product sales in a given industry or company, on a quarterly or annual basis. These indicators inform about the degree of involvement in creation of new products and development of new technologies, and at the same time characterize the level of competence of various industries and enterprises in the area of product innovation. The level of innovation activity intensity indicators shows a strong correlation with the competition intensity indicator in the area of new products, which should force enterprises to maintain the technology used at appropriate level.

4.2. Measures of innovativeness of production enterprises

Indicators of the intensity of innovative activity (IAI), research and development (RDI), marketing of new products (NPMI) change over time and show changes in the technological strategy of companies operating in individual branches of industry. Strong changes reflect the lack of stabilization of enterprise market position or the industry.

For the clarity in Table 3, the above mentioned indicators are presented with their comprehensive description, and some indicators are discussed with reference to their usefulness and limitations, when applied in practice by a manufacturing company.

Table 3. Description of innovativeness and technological competitiveness indicators in manufacturing companies

Innovative Activity Intensity (IAI)	The percentage ratio of expenditure on innovation, to the total value of product sales in a given industry or company, on an annual or quarterly basis	Annual or quarterly strong dynamic changes reflect the lack of stabilization of enterprise market position or the industry
Research and Development Intensity (RDI)	The percentage ratio of expenditure on research and development activities to the total value of product sales in a given industry or company, on an annual or quarterly basis	Annual or quarterly strong dynamic changes reflect the lack of stabilization of enterprise market position or the industry
New Product Marketing Intensity (NPMI)	The percentage ratio of expenditure on marketing of new and modernized products to the total value of product sales in a given industry or company, on an annual or quarterly basis	Annual or quarterly strong dynamic changes reflect the lack of stabilization of enterprise market position or the industry
Innovation Engagement (IE)	The percentage ratio of expenditure on innovation to the total value of investment expenditure in a given industry or company on an annual basis	Insufficient innovation commitment to bring new products to market is one of the key internal factors in new product failure
Research and Development Engagement (RDE)	The percentage ratio of expenditure on research and development to the total value of investment expenditure in a given industry or company on an annual basis	Insufficient R&D commitment to bring new products to market is one of the key internal factors in new product failure
New Product Marketing Engagement (NPME)	The percentage ratio of expenditure on new products marketing to the total value of investment expenditure in a given industry or company on an annual basis	Insufficient marketing commitment to bring new products to market is one of the key internal factors in new product failure

Table 3 cont.

New Product Sales Index (NPS)	Marketing product offer renewal is the percentage ratio of the value of new product sales to the total sales value (of a specific company or industry) in a given year	The indicator informs about the degree of renewal of the marketing offer (product portfolio). In this approach, new products or significantly improved (modernized) products, which are new, at least from the point of view of the enterprise introducing them, are classified as technological innovations
Patent Activity Index (PAI)	The percentage ratio of the number of patents obtained by the enterprise in a given year (or in a given technology department, in a given country) to the employment in research and development (full-time equivalent, one can take into account the size of the project team, the number of project teams)	The implementation of the Quick Patent procedure in the enterprise significantly increases the number of patents and invention applications
Inventive Activity Index (IAI)	The percentage ratio of the number of inventions obtained by the enterprise in a given year (or in a given technology department, in a given country) to the amount of employment in research and development activities (the size of the project team, the number of project teams can be taken into account)	The Patent Prosecution Highway ensures a faster procedure that have a particularly rigorous approach to patents and invention submitted

Source: Author's own elaboration.

The author assumes that the measure of intensity of competition on a market for new products is the indicator expressed by the formula:

$$SR_U = \frac{SB_{NPi} - SP_{NPi}}{SB_{NPi}} \quad \text{or} \quad SR_S = \frac{WSB_{NPi} - WSP_{NPi}}{WSB_{NPi}}$$

where:

$SR_{(u,s)}$ – the rate of competition (according to the share of sales (u) or sales (s)) in new products market;

SB_{NPi} – share of sales of *i*-th new products (product type, product line) in the industry in the total sales value of products in a given industry (or WSB_{NPi} – sales value of the *i*-th new product (product type, product line) by all companies in a given industry);

SP_{NPi} – share of sales of the i-th new product (product type, product line) in a given company in the total sales value in a given industry (or WSP_{NPi} – sales value of the *i*-th new product (product type, product line) in a given company);
$SB_{NPi} - SP_{NPi} > 0$; $WSB_{NPi} - WSP_{NPi} > 0$;
$SR_{(u,s)} < 0,5$ – very low intensity of competition on a new products market;
$0,5 \leq SR_{(u,s)} < 0,65$ – weak;
$0,65 \leq SR_{(u,s)} < 0,80$ – average;
$0,80 \leq SR_{(u,s)} < 0,95$ – strong;
$0,95 \leq SR_{(u,s)} < 1,0$ – very strong intensity of competition on a new products market.

The index of the intensity of competition of a new product offer on the market (SR) reflects the level of competitiveness of a new product offer of a given enterprise or industry. It basically determines the ability of the company's new market offer to participate in smooth adjustment processes in the changing market conditions. It shows how companies compete on the market of new products for the favor of customers, the degree of customer acceptance of the new product offer. Therefore, this index shows the ability to survive on the market, as well as the ability to develop the company under certain conditions of competition.

The level of intellectual resources development is reflected in values of ratios of total innovation engagement (IE), research and development (RDE) and new product marketing (NPME) to investment outlays in industrial spheres. These indicators determine the stage of development of industry/company and changes in market absorption of its products, i.e., the intensity of demand depending on the needs and preferences of buyers. According to F. Kodama (1995), in particular, the RDE index is a measure of the degree of transformation of companies/industry from producing organizations to knowledge-oriented organizations. The development of intellectual resources is a derivative of expenditure on research and development and here it is compared with the expenditure on expansion or modernization of production systems.

From the point of view of a given enterprise, the average level of the NPS index for a given industry or the entire industry has a significant informative value. The sales rate of new products in a given enterprise, which is above (favorable situation) or below the average value (unfavorable situation), determines different normative strategic decision variants. This indicator also informs about the equilibrium state of the marketing offer, which is in different phases of

the market life cycle. An NPS level, below the industry or industry average, indicates the need to implement a new product strategy. However, the development of the NPS index above the average level determines possibilities of intensifying activities through market penetration and growth (product improvement and maintaining contacts with customers).

5. Discussion

Competence-based theory (Hunt & Lambe, 2000) is also an 'internal factors' theory and it complements resource-based theory (RBT) because it explains how firms develop strategies to exploit resources in their quest for competitive advantage. In fact, it is argued that competence-based theory (CBT) is a logical extension of RBT. Numerous theoretical and empirical articles (e.g., Prahalad & Hamel, 1990; Ritter & Gemünden, 2004) have been developing CBT and the idea of core competencies is the pivotal section of the paper. In addition, an enterprise must manage its competencies as a system and avoid excessive focusing of managerial attention on developing and managing a 'single competence' judged by some criteria to be 'core'. Moreover, it is that CBT employs assets and capabilities in the description of competencies – further blurring the boarders between these suggested concepts (Hunt & Lambe, 2000; Piening & Salge, 2015).

Market-based resources are those that can immediately be deployed in the market place to directly create or maintain competitive advantage. Marketing--support resources, however, serve primarily to support marketing activities, especially in product innovation, and hence contribute indirectly to competitive advantage, the same technological activities.

The author assumes that the market resources of each production company determine its chances in the competitive environment, but also such market resources as the reputation and credibility of the company among its customers, suppliers and distributors, determine the company's ability to effectively introduce innovations on the market. Moreover, in their consideration of performance a distinction is made between technical performance and market performance. Therefore, there is a need to constantly monitor internal innovation processes and the situation in marketing environment to undertake new product projects with a high probability of success in the future. Thus, it is important to determine, what metrics/indicators can be used by these companies to measure the product innovation process competencies.

The use of indicators tends to bring better analytical capacity in management information system, regardless of the target industry. Hence a single--dimension analysis may generate measurement bias of product innovations when empirical work is concerned, especially upon industry comparison, since each has a specific dynamics, thus the innovative effect is neither adequately observed, nor captured (Zizlavsky, 2016).

Since indicators measure different aspects of innovation, it is important for researchers to bear in mind the types of information that are actually subject to retrieval. Hence R&D expenses are fairly illustrative of company's innovative efforts, patents stand for the levels reached in innovative production, patent citations, on their part, are indicative of an innovative product's the quality, while product announcements objectively signal the level of product innovation (Kleinknecht, Montfort, & Brouwer, 2002; Taques et al., 2020). Therefore, when possible, all indicators speak particularly clearly for the level of competencies in the area of companies innovativeness.

Technological strategy has crucial relevance for manufactures. Therefore, the importance of adopting multi-dimensional indicators may be discussed in the means of covering innovation-related effects from various viewpoints. Indicators have actually been proposed so far, but the number of available studies linking input and output is still limited, hindering an in-depth analysis of innovation impact (Dziallas & Blind, 2019). Studies combining indicators can definitely provide a better understanding of product innovation competencies in industrial enterprises.

6. Conclusions

The findings are based on the literature and expert studies. It is not expected that the metrics presented here are fully exhaustive or provide an immediate 'silver bullet' for innovation project success. The benefits of adoption of any type of measure depend on who is using the measures. Different kinds of managerial biases (e.g., group thinking, pet projects, and confirmation bias) can hamper the potentially useful information available. Nevertheless, the study does discuss immediate and pertaining issues with using established competencies metrics for product innovation process. The study provides useful metrics that can be part of a more holistic and effective assessment of innovation projects.

The conducted literature research led to the following conclusions that can make valuable contributions to management science (Griffin & Page, 1996; Hansen, Nohria, & Tierney, 1999; Kristiansen & Ritala, 2018; Rutkowski, 2016):

- there is currently no consistent methodology for examining competencies in the area of product innovation, using the rules of concurrent engineering, i.e., parallel development of a new product;
- companies use fragmented and not in all phases available methods, techniques and tools for controlling activity in the product innovation process;
- there is an unclear and ambiguous distinction between 'hard' and 'soft' performance measures, the implications of their use are unclear;
- in general, internal measures of efficiency in the design and development of a new product focus on comparing activities and processes with previously performed operations and achieved goals; the measures used often do not take into account the different nature of products, processes and customer needs;
- there is no set of measures model for assessing production company competencies in the area of product innovation, therefore the measures should be flexibly adapted to the information needs of new product development team and company's management.

The presented set of indicators and the proposed universal concept of measuring production enterprise competencies in the field of product innovations in the context of technical and marketing strategies can be used by scientists and managers in research on the innovativeness of enterprises and industries. The indicators of intensity of competition on a new product market have an important informative value and can fill the information gap, thus reduce the risk in the process of making managerial decisions regarding the new product development strategy in industrial enterprises.

This study helps practitioners identify the growth level of a firm's resources and its influences on product innovations. This characterization can serve as an indicator benchmark for managers to define technology and marketing strategies and policies to stimulate product innovation. So far, the conclusions indicate that the one-dimensional use of a product innovation indicator is restrictive to understand the new product innovation process. For example, Boone, Lokshin, Guenter, & Belderbos (2019) argued that patents offer consistency and objectiveness, because examiners may validate new inventions on their utility, an important point to measure innovation. In contrast, Jin, García, & Salomon (2019) discussed that while patents may be ideal to some industries, the new product sales indicator might be more appropriate to others.

The limitations of the research include a complex character of considered theoretical constructs. A significant limitation may also be the access to statistical information needed to calculate proposed indicators. The sets of measures must be adapted to the information needs of a specific enterprise. Therefore, a future study should seek to construct a more robust model, to consider the causal relationship between competencies or capabilities and organizational performance.

References

Barczak, G. (1995, June). New product strategy, structure, process and performance in the telecommunications industry. *Journal of Product Innovation Management, 12*(3), 224-234. https://doi.org/10.1111/1540-5885.1230224

Blindenbach-Driessen, F., van Dalen, J., & van den Ende, J. (2010, July). Subjective performance assessment of innovation projects. *Journal of Product Innovation Management, 27*(4), 572-592. https://doi.org/10.1111/j.1540-5885.2010.00736.x

Boone, C., Lokshin, B., Guenter, H., & Belderbos, R. (2019, February). Top management team nationality, corporate entrepreneurship, and innovation in multinational firms. *Strategic Management Journal, 40*(2), 277-302. https://doi.org/10.1002/smj.2976

Carboni, O. A., & Russu, P. (2018, March). Complementarity in product, process, and organizational innovation decisions: Evidence from European firms. *R&D Management, 48*(2), 210-222. https://doi.org/10.1111/radm.12284

Castellion, G., & Markham Stephen, K. (2013, September). Myths about new product failure rates perspective: New product failure rates: Influence of Argumentum ad populum and self-interest. *Journal of Product Innovation & Management, 30*(5), 976-979. https://doi.org/10.1111/j.1540-5885.2012.01009.x

Commission Regulation (EC) No. 1450/2004 of 13 August 2004 implementing Decision No. 1608/2003/EC of the European Parliament and of the Council concerning the production and development of Community statistics on innovation. Retrieved from https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:267:0032:0035:EN:PDF

Cooper, R. G. (2017). *Winning at new products: Creating value through innovation* (5th ed.). New York: Basic Books.

Cooper, R. G., & Edgett, S. J. (2003). *Benchmarking best practices performance results and the role of senior management*. Hamilton, IN: Product Development Institute. Retrieved from https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.876.7436&rep=rep1&type=pdf

Heij Cornelis, V., Volberda Henk, W., Van den Bosch Frans, A. J., & Hollen Rick, M. A. (2020, March). How to leverage the impact of R&D on product innovation? The moderating effect of management innovation. *R&D Management, 50*(2), 277-294. https://doi.org/10.1111/radm.12396

Dziallas, M., & Blind, K. (2019, February-March). Innovation indicators throughout the innovationprocess: An extensive literature analysis. *Technovation, 80-81*, 3-29. https://doi.org/10.1016/j.technovation.2018.05.005

Engelman, R. M., Fracasso, E. M., Schmidt, S., & Zen, A. C. (2017). Intellectual capital, absorptive capacity and product innovation. *Management Decision, 55*(3), 474-490. https://doi.org/10.1108/MD-05-2016-0315

Githens, G. D. (2002, October). NPD viewpoint: Developing and using predictive metrics – A useful supplement to „reactive" metrics. *Visions*.

Griffin, A., & Page, A. L. (1996, November). The PDMA success measurement project: Recommended measures for product development success and failure. *Journal of Product Innovation Management, 16*(6), 478-496. https://doi.org/10.1111/1540-5885.1360478

Grzegorczyk, T., & Głowiński, R. (2020). Patent management strategies: A review. *Journal of Economics & Management, 40*(2), 37-39. https://doi.org/10.22367/jem.2020.40.02

Hansen, M. T., Nohria, N., & Tierney, T. (1999). What is your strategy for managing knowledge? *Harvard Business Review, 77*(2), 106-116. Retrieved from https://hbr.org/1999/03/whats-your-strategy-for-managing-knowledge

Hervas-Oliver, J. L., Sempere-Ripoll, F., Boronat-Moll, C., & Rojas-Alvarado, R. (2018). On the joint effect of technological and management innovations on performance: Increasing or diminishing returns? *Technology Analysis & Strategic Management, 30*, 569-581. https://doi.org/10.1080/09537325.2017.1343462

Hisrich, R., & Kearney, C. (2012). *Corporate entrepreneurship: How to create a thriving entrepreneurial spirit throughout your company*. New York, NY: McGraw-Hill.

Hoffmann, T. (1999). The meanings of competency. *Journal of European Industrial Training, 23*(6), 275-285. https://doi.org/10.1108/03090599910284650

House, C. H., & Price, R. L. (1991). The return map: Tracking product teams. *Harvard Busineess Review, 69*(1), 92-100. Retrieved from https://hbr.org/1991/01/the-return-map-tracking-product-teams

Hunt, S. D., & Lambe, C. J. (2000, March). Marketing's contribution to business strategy: Marketing orientation, relationship marketing and resource-advantage theory. *International Journal of Management Reviews, 2*(1), 17-44. https://doi.org/10.1111/1468-2370.00029

Jajja, M. S. S., Kannan, V. R., Brah, S. A., & Hassan, S. Z. (2017). Linkages between firm innovation strategy, suppliers, product innovation, and business performance: Insights from resource dependence theory. *International Journal of Operations & Production Management, 37*(8), 1054-1075. https://doi.org/10.1108/IJOPM-09-2014-0424

Jin, B., García, F., & Salomon, R. (2019). Inward foreign direct investment and localfirm innovation: The moderating role of technological capabilities. *Journal of International Business Studies, 50*(5), 847-855. https://doi.org/10.1057/s41267-018-0177-1

Juchniewicz, M., & Grzybowska, B. (2010). *Innowacyjność mikroprzedsiębiorstw w Polsce* [Innovativeness of micro-enterprises in Poland]. Warszawa: Polska Agencja Rozwoju Przedsiębiorczości.

Kasprzak, W., & Pelc, K. (1999). *Wyzwania technologiczne – prognozy i strategie* [Technological challenges – forecasts and strategies]. Kraków: Wydawnictwo Profesjonalnej Szkoły Biznesu.

Kasprzak, W., & Pelc, K. (2012). *Innowacje, strategie techniczne i rozwojowe* [Innovations, technical and development strategies]. Wrocław: Oficyna Wydawnicza Politechniki Wrocławskiej.

Kirsner, S. (2015). What big companies get wrong about innovation metrics. Retrieved from https://hbr.org/2015/05/what-big-companies-get-wrong-about-innovation-metrics

Khosravi, P., Newton, C., & Rezvani, A. (2019, December). Management innovation: A systematic review and meta-analysis of past decades of research. *European Management Journal, 37*(6), 694-707. https://doi.org/10.1016/j.emj.2019.03.003

Kleinknecht, A., Montfort, K. V., & Brouwer, E. (2002). The non-trivial choicebetween innovation indicators. *Economics of Innovation and New Technology, 11*(2), 109-121. https://doi.org/10.1080/10438590210899

Kodama, F. (1995). *Emerging patterns of innovation*. Boston: Harvard Business School Press.

Krawiec, F. (2000). *Zarządzanie projektem innowacyjnym produktu i usługi* [Managing an innovative product and service Project]. Warszawa: Grifin.

Kristiansen, N. J., & Ritala, P. (2018). Measuring radical innovation project success: Typical metrics don't work. *Journal of Business Strategy, 39*(4), 34-41. https://doi.org/10.1108/JBS-09-2017-0137

Magnier-Watanabe, R., & Benton, C. (2017). Management innovation and firm performance: The mediating effects of tacit and explicit knowledge. *Knowledge Management Research & Practice, 15*(3), 325-335. https://doi.org/10.1057/s41275-017-0058-6

Neely, A. (1998). *Measuring business performance*. London: The Economist in Association with Profile Books.

OECD/Eurostat. (2018). *Oslo Manual 2018: Guidelines for collecting, reporting and using data on innovation* (4th ed.; The Measurement of Scientific, Technological and Innovation Activities). Paris/Luxembourg: OECD Publishing/Eurostat. https://doi.org/10.1787/9789264304604-en

Piening, E. P., & Salge, T. O. (2015, January). Understanding the antecedents, contingencies, and performance implications of process innovation: A dynamic capabilities perspective. *Journal of Product Innovation Management, 32*(1), 80-97. https://doi.org/10.1111/jpim.12225

Prahalad, C. K., & Hamel, G. (1990, May-June). The core competence of the corporation. *Harvard Business Review*, 79-91. Retrieved from http://www.personal.psu.edu/kkm11/files/HandP_Core%20Competence%20of%20the%20organization.pdf

Reinertsen, D. G., & Smith, G. P. (2001). *Developing products in half the time*. New York, NY: Van Norstrand Reinhold.

Ritter, T., & Gemünden, H. G. (2004, May). The impact of a company's business strategy on its technological competence, network competence and innovation success. *Journal of Business Research, 57*(5), 548-556. https://doi.org/10.1016/S0148-2963(02)00320-X

Rutkowski, I. P. (2007). *Rozwój nowego produktu. Metody i uwarunkowania* [New product development. Methods and conditions]. Warszawa: Polskie Wydawnictwo Ekonomiczne.

Rutkowski, I. P. (2016). *Metody innowacji produktu. Macierzowo-sieciowe metody pomiaru dojrzałości procesu innowacji produktu* [Product innovation methods. Matrix-network methods for measuring the maturity of the product innovation process]. Poznań: Wydawnictwo Uniwersytetu Ekonomicznego w Poznaniu.

Smith, K. H. (2005). Measuring innovation. In J. Fagerberg, D. C. Mowery, & R. R. Nelson (Eds.), *The Oxford handbook of innovation* (pp. 148-177). New York, US: Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199286805.003.0006

Taques, F. H., Lopez, M. G., Basso, L. F., & Areal, N. (2020, January-March). Indicators used to measure service innovation and manufacturing innovation. *Journal of Innovation & Knowledge, 6(1),* 11-26. https://doi.org/10.1016/j.jik.2019.12.001

Wodecka-Hyjek, A. (2013). Wybrane narzędzia pomiaru innowacyjności [Selected tools for measuring innovation]. *Zeszyty Naukowe. Zarządzanie, 998*, 63-82. https://doi.org/10.15678/ZNUEK.2013.0922.04

Zizlavsky, O. (2016). Innovation performance measurement: Research into Czech business practice. *Economic Research, 29*(1), 816-838. https://doi.org/10.1080/1331677X.2016.1235983