

## PROBLEMS OF COMPLEX EVALUATION OF PRODUCTION PROCESS EFFICIENCY

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**Abstract** Analysis of production process efficiency is an essential analytical tool of each enterprise. Focusing on market competitiveness, managers are forced to use increasingly detailed analysis of processes occurring in enterprise. Analysis of production process efficiency is not clearly defined in the scientific literature, making it difficult to correct use in business practice. In this article the authors present problems of properly define the production efficiency in the scientific literature and analyze problems of utilization of these methods in the research of economic practice.

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## 1. INTRODUCTION

Productive activity of companies is dependent on internal as well as external conditions of their functioning. Customers' requirements concerning products are growing and are being individually analyzed all the time. Such situation makes the rules of acting on the market and creates very strict conditions. Fast technological development leads to creating new technologies and shortens the life of products. Using of resources, materials, power supplies and other components necessary in a production process causes not only economic but also ecological threats. Presented factors have a major impact on the efficiency of production process.

Production efficiency is a very important issue from the point of view of processes organized in a company and in a supply chain. Improving the efficiency of a production process is therefore a very important factor in controlling actions. Nevertheless, it needs to be remembered that aiming at maximising production efficiency can entail numerous threats. The most dangerous traps of maximising production efficiency are:

- lack of coordination in realization of operational aims of individual departments with strategic aims of a company or a supply chain,
- discrepancy between strategic aims formulated by individual companies which are elements of a supply chain,
- discrepancy between operational aims of different departments of a company,
- threat of a negative influence on the surrounding environment.

Comprehensive analysis of efficiency requires both an operational data relating to technological process, supported by assist processes and service, but also the data generated by an information system in order to ensure their reliability and timeliness. For this reason, the efficiency analysis should ultimately affect the production process, taking into account both the material flow (Michłowicz & Smolińska, 2015, pp. 27-30) and information flow, as well as the aspects of production management and existing feedback. The efficiency of the production process is a specific problem area that requires the analysis from the point of view of placing the problem in the field of management science. It should be noted that the focus on the benefits and economy effects, taking into account any dimension of this activity is the domain of management of economy process. Based on that sentence, it must be acknowledged that the efficiency analysis of production process, including both the analysis of the production resources, the cost of logistics, material procurement and the flow of information throughout the material flow chain, classifies this research problem in the field of management science, with particular regard to the specifics of the analyzed process.

## 2. THE PROBLEM OF DEFINING OF PRODUCTION PROCESS EFFICIENCY

Production efficiency is a concept which is quite difficult to define. Generally efficiency can be defined as a measurement (usually expressed as a percentage) of the actual output to the standard output expected. Efficiency measures how well something is performing relative to existing standards; in contrast, productivity measures output relative to a specific input, e.g., tons/labor hour. Efficiency is the ratio of (APICS, 2004):

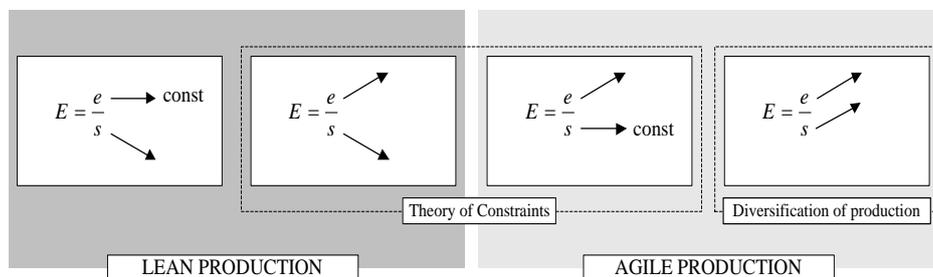
- actual units produced to the standard rate of production expected in a time period,
- standard hours produced to actual hours worked (taking longer means less efficiency),
- actual volume of output in value to a standard volume in a time period in value.

In economic aspect efficiency is the result of company's activity, which is a proportion of the achieved effect to borne spending:

$$E = \frac{e}{s} \quad (1)$$

where:

E – efficiency; e – effects; s – spending



**Fig. 1** Attributing methods of improving efficiency to chosen concepts of managing, Own study (Kolinski, 2013, p. 96)

Complexity of production management is supported by a number of managing concepts which are implemented in order to improve production efficiency. According to model (1) we can distinguish few methods of improving efficiency of actions (Kolinski, 2013, p. 96):

- lowering spendings and keeping the level of effects at the same time,
- lowering spendings and raising the level of effects at the same time,
- keeping the level of spendings and raising the level of effects at the same time,

- raising the level of spendings and raising drastically the level of effects at the same time.

Figure 1 shows basic methods of improving production efficiency and attributing them to chosen concepts of management.

The basis of the above picture is conviction that Lean Production concept concentrates on lowering spending by, among others, lowering the level of expenses. Agile Production concept, on the other hand, does not focus on expenses optimisation. Therefore, the methods of improving efficiency which did not concern lowering spending were recognised as characteristic of Agile Production concept. Theory of Constraints concentrates on two methods of improving efficiency: improving effects and keeping spending as well as improving process and lowering spending (e.g. reducing the supply of work in progress). According to the definition of production diversification (Kenny, 2009), raising effects is possible thanks to increasing spending (e.g. introducing new products or entering new markets).

**Table 1** Chosen definitions of efficiency in the aspect of managing production, Source: own study based on (APICS, 2004)

<b>Allocative efficiency</b>	The use of resources to produce those goods and services most wanted by consumers.
<b>Efficiency variance</b>	In cost accounting, the difference between the actual volume of a resource used and the budgeted volume, multiplied by the budgeted or standard price.
<b>Line efficiency</b>	A measure of actual work content versus cycle time of the limiting operation in a production line. Line efficiency (percentage) is equal to the sum of all station task times divided by the longest task time multiplied by the number of stations.
<b>Manufacturing cycle efficiency</b>	The ratio of value-added time to manufacturing lead time or cycle time. Manufacturing cycle time can be improved by the reduction of manufacturing lead time by eliminating non-value-added activities such as inspecting, moving, and queuing.
<b>Materials efficiency</b>	A concept that addresses the efficiency with which materials are obtained, converted, and shipped in the overall purchasing, production, and distribution process.
<b>Operating efficiency</b>	A ratio (represented as a percentage) of the actual output of a piece of equipment, department, or plant as compared to the planned or standard output.
<b>Performance efficiency</b>	A ratio, usually expressed as a percentage, of the standard processing time for a part divided by its actual processing time. Setups are excluded from this calculation to prevent distortion.
<b>Productivity</b>	An overall measure of the ability to produce a good or a service. It is the actual output of production compared to the actual input of resources. Productivity is a relative measure across time or against common entities (labor, capital, etc.).
<b>Worker efficiency</b>	A measure (usually computed as a percentage) of worker performance that compares the standard time allowed to complete a task to the actual worker time to complete it.
<b>Labor efficiency</b>	The average of worker efficiency for all direct workers in a department or facility.
<b>Labor efficiency variance</b>	Labor efficiency variance is (actual number of hours worked minus standard number of hours worked) times standard labor wage rate. The variance is unfavorable if the actual hours exceed the standard hours.

In APICS dictionary one can find numerous definitions which can be analysed when assessing production efficiency. Table 1 presents chosen definitions of efficiency in the aspect of managing production.

Literature analysis only confirms the complexity of production efficiency. Most organizations say they are continually trying to increase their productivity. There are really four ways of doing this (Waters, 2002, p. 294):

- improve effectiveness with better decisions,
- improve efficiency using fewer inputs to achieve the same outputs,
- improve performance in some other way such as higher quality, fewer accidents, less disruption,
- improve morale to give more co-operation and incentives.

The problem of production efficiency is based not only on economic aspects and the standards for setting and assessing these aspects. The effectiveness of assessing operating efficiency depends on the skill of transposing strategic aims to tactical and operating levels. Effective execution of strategic plan needs its translating into action, task results and indicators of everyday activities. The success on the market is attainable by communicating strategic and operating goals on the each level of organisational structure and their connecting with budget of units or employee motivation (Śliwczyński, 2011a). For this reason operating efficiency deals with the issue of optimisation and rationalisation of a production process in its organisational and technological aspects. Figure 2 shows the place of operating efficiency in the model for assessing production efficiency.

**Fig. 2** The place of operating efficiency in the model for assessing production efficiency, Source: Own study (Koliński, Śliwczyński & Golińska, 2014, p. 285)

Production efficiency		
Economic efficiency		Operating efficiency
Efficiency of the Organization	Efficiency of the Process	Efficiency of the Work Station

The present collation is based on efficiency division presented by G. Rummler, A. Brache (1995) and including the distinction between economic efficiency and operating efficiency. Analysis and evaluation of the production process efficiency in operating aspect should therefore take into account:

- the analysis of the performance of the evaluated production process,
- availability of working machines and equipment,
- allocation of production tasks to individual work stations.

In its detailed analysis of the above factors, it should be noted their connections of cause and effect relationships, and possible feedback. For this reason, the above factors complemented a selection criteria of strategies can be classified as basic analytical ranges in terms of operating efficiency of the production process.

The distinction of the production efficiency in these two aspects<sup>1</sup> is necessary due to the possibility of obtaining complex analysis of the production process. Taking into account the economic and operating aspects, can be:

- analyze the relationships between the indicators in economic and operating terms (Kolińska & Cudziło, 2014, pp. 26-27),
- use feedback both within their respective areas of analysis, as well as between the analysis of economic and operating efficiency,
- to link the results obtained with the fundamental objectives, established at the strategic level.

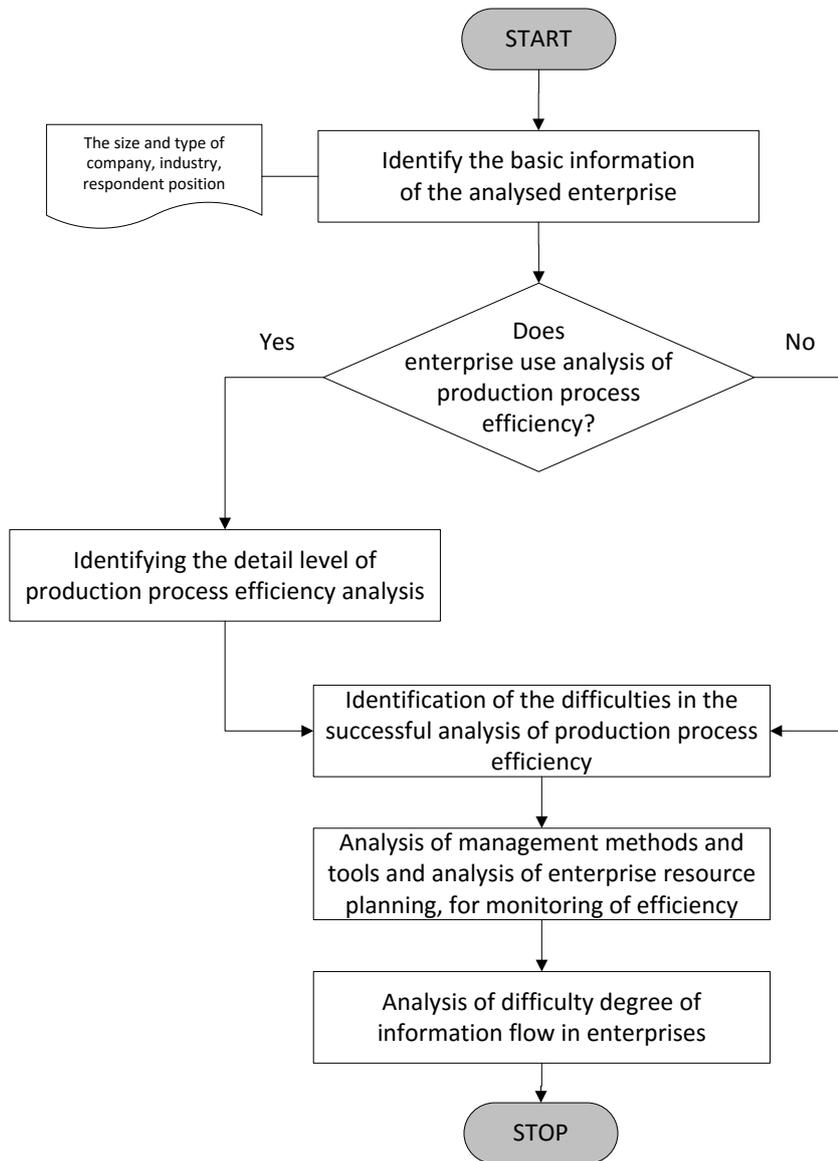
### **3. THE PROBLEM OF ANALYSIS USE OF PRODUCTION PROCESS EFFICIENCY IN BUSINESS PRACTICE**

Successful assessment of production efficiency requires use of current and complex generated input data. It should be noted that despite numerous references in the literature about the efficiency, the efficiency analysis in business practice is not applied so as to provide successful support decision-making in the enterprise. The present proposal was the main premise to conduct a research in this field. Figure 3 presents the methodology of perform the audit analyzes of production efficiency utilization and the major limitations of its application in business practice.

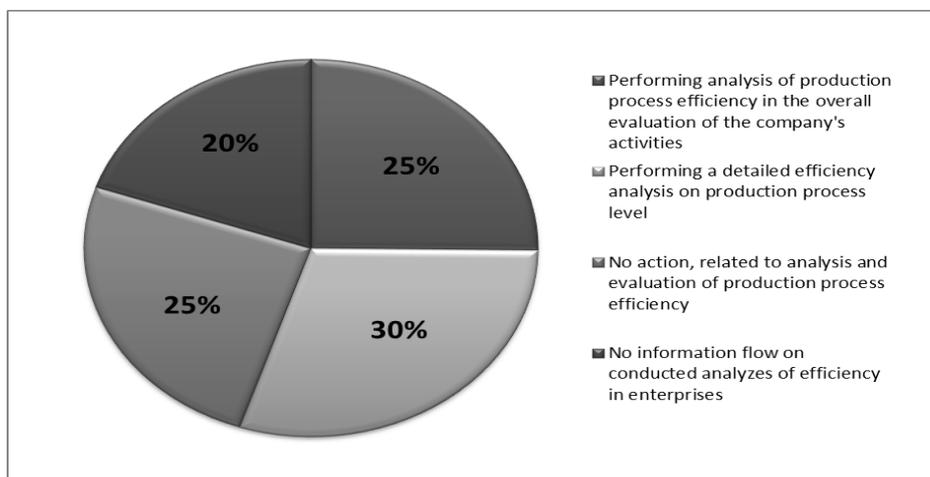
The research study has been carried out using a questionnaire method and some of the studied subjects allowed to do make observations and direct interviews in the companies. This research is a clarification and updating the studies carried in 2012 and presented in publications (Kolińska & Koliński, 2013) (Fajfer, Koliński & Kolińska, 2013). The research study was carried out in the first two quarters of 2015 in 147 production companies in Greater Poland's region. The questionnaire consisted of six questions, which include open-ended questions and multiple choice. The studied companies in over 74% represented medium and large companies. The main aim of carried research studies was to identify the degree of use of production process efficiency and difficulties in their application in business practice.

Results of the research indicate that 46% of surveyed companies didn't declared using the efficiency analysis to monitor and assess production processes or they not aware of that fact. Despite the fact that 54% of surveyed companies rely on analysis of production process efficiency, then we should consider this as a unsatisfactory result. This result confirm the generally prevailing opinion that the efficiency analysis is a complicated process and difficult to use in business practice. This is due to the lack of universal analytical tools to support its implementation. However, the results also indicate an increase in awareness of the need for efficiency analysis in order to improve the competitive position on the market. Detailed data

regarding use degree of analysis of production process efficiency, in practice, is shown in Figure 4.



**Fig. 3** Methodology of perform the audit analyzes of production efficiency utilization in business practise, Source: Own study



**Fig. 4** Use degree of analysis of production process efficiency, Source: Own research

Further investigation of the use of analysis of production process efficiency in business practice, was related to common problems in a reliable its execution. The most important factor that interferes a proper execution of efficiency analysis, is a problem with the current information flow between departments in the enterprise. This problem is largely due to difficulties of comprehensive mapping of business processes in the IT system supporting enterprise management. Computerization of analysis of production process efficiency is an issue that requires separate conceptual consideration and simulation<sup>2</sup>. The most frequent difficulties in the successful analysis of production process efficiency, are shown in Table 2.

Analysing the reasons of difficulties in the successful analysis of production process efficiency, over 74% of the surveyed companies admitted that the lack of comprehensive evaluation methods is an essential factor in the occurrence of difficulties showed in Table 2. A similar trend have reasons for not using evaluation results of efficiency analysis. 83.14% of companies indicate the lack of a comprehensive assessment methods as the primary factor impeding to make analysis and assess of production process efficiency. This result should be seen as a basic premise explaining the need to develop a comprehensive evaluation model of production efficiency.

While analyzing the results of research in terms of difficulties related to the information flow, it should also be noted that the problem of information system integration in the enterprise represents 23% of all identified problems. The other hand the problem of confusion terms relating to used management concepts and the absence of a competent person to perform a comprehensive analysis of efficiency represents 8% and 10%. These results identified at the stage of the first studies in this field, have led to conduct in-depth studies and observations of the information flow in the enterprise. The author's opinion this issue has a direct impact on the

quality of input data necessary for successful analysis and evaluation of production process efficiency.

**Table 2** Difficulties in the successful analysis of production process efficiency

No	Problem	Number of replies*	Percentage
1	The problem with current flow of information between departments in enterprise	68	23%
2	Problems related to the implementation of the strategy chosen by the enterprise	20	7%
3	Problems related to job scheduling of production constraints (work station with the lowest performance - the bottleneck)	23	8%
4	Problems with the reliable determination of real performance of production proces	19	6%
5	Difficulties in collecting relevant data for efficiency analysis	12	4%
6	Lack of tools supporting analysis and assessment of processes efficiency	12	4%
7	Difficulties of the correct interpretation of implemented management tools (resulting confusion)	29	10%
8	Problems with transposing of strategic objectives to operational and current plans	22	7%
9	Problems related with the appropriate distribution of machine performance to the production of individual products or production orders	32	11%
10	Problems related to planning of a balanced use of workstations	38	13%
11	Lack of responsible person or department for making such analysis	24	8%
<b>Total</b>		299	100%

**\* Surveyed enterprises were able to choose more than one answer.**

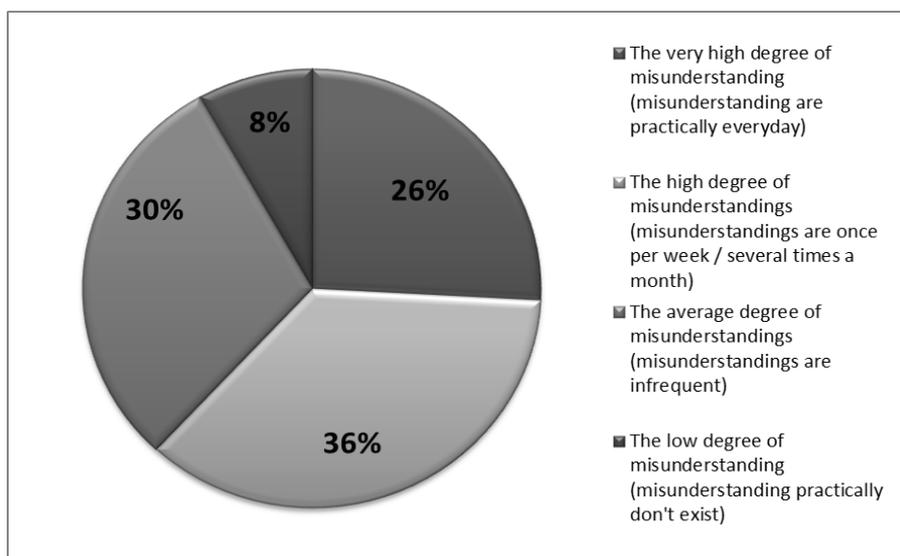
Within the project Science closer to business, business closer to science<sup>3</sup> co-author conducted interviews and observations among employees of 30 companies of various industries and sizes, doing business in the Greater Poland's region. The preliminary research conducted in 2012 by survey combined with direct interview<sup>4</sup>. The second stage of the research conducted in the first two quarters of 2015 under the uniform tests used to identify problems in efficiency evaluation in business practice. This was due to necessity to enlarge a statistical sample and upgrade the results from the research in 2012. Analysis of resource efficiency confirms that computerization – and thus, the ability to monitoring of all processes in enterprises and throughout the supply chain in real time – is an important factor in the growth market competitiveness. The issue of integration of knowledge transfer in the en-

terprise and supply chain have been widely described in the scientific literature. However, it was an innovative approach to solving the existing problems enables a significant increase in efficiency.

One of the factors analyzed in the framework of research by observation, interviews and surveys, was to evaluate the use of methods and tools for management and evaluate of enterprise resource planning that allow monitoring of the processes efficiency.

In 68% of surveyed enterprises stated that the methods and tools of management and resource planning are used. Conversely, companies that do not use the methods and tools for management and resources planning, account for 21% of all surveyed enterprises. In addition, it should be noted that companies that not using the methods and tools for management in 100% come from the SME sector, while as 71% of this group were micro and small enterprises. Other representatives of companies (11%, of which 66% were SMEs) didn't know whether their company used these methods and tools.

The analysis results were further supported by the assessment of factors influencing the lack of use of these management tools, made in the form of direct interviews. These results indicate that especially micro and small enterprises are not aware of the need for business the methods and tools for resource management and planning. Another reason for such a result can be the lack of information provided to workers, who participated in this study. However, it should be noted that these methods are mostly used in large enterprises (46% positive answers were given by large enterprises).



**Fig. 5** Analysis of confusion degree in enterprises, Source: Own research

Another element of the study was to assess the difficulty degree of information flow in enterprise. Figure 5 shows the incidence of misunderstanding between employees that are associated with different interpreting of used management tools and realised projects.

In over 70% of companies we identified misunderstandings as one of the main difficulties complex analysis evaluation of production process efficiency. The use of IT tools containing unreliable data can lead to the opposite of the intended effect, because management decisions are based on incorrect data. Therefore, analysis of misunderstandings that result from unreliable data and incomplete analysis on the basis of which the decisions were taken, is necessary.

The flow of wrong information has a very negative impact on the efficiency of processes in enterprise. Lack of equal analyze the production process and interpretation of results makes it impossible complete analysis according to the strategic objectives of enterprise. The integration of information flow is possible through the use of IT systems supporting management and decision making (Nowicka-Skowron, 2002, p. 25). In the market we can find a lot of offers for information systems supporting processes in enterprise, as well as dedicated systems for detailed analysis of selected processes. The use of specific tools requires a detailed analysis of the theoretical assumptions of methods and techniques for evaluation efficiency, as well as the degree of their use in business practice.

#### 4. CONCLUSION

Presented in this chapter analyzes and conclusions are the result of many years of research, conducted by the authors in terms of efficiency and logistics controlling, with particular regard to production logistics. The seemingly large number of publications, both Polish language and foreign on this issue doesn't allow to standardize evaluation methods of production process efficiency. Complex analysis of production process efficiency must include economic and operational aspects. Testify to the fact Authors publications (Śliwczyński, 2011a) (Śliwczyński, 2011b) (Koliński, 2012) (Koliński, 2013) (Koliński & Koliński, 2013) (Koliński, Śliwczyński & Golińska, 2014). A separate issues is to evaluate the use degree of IT tools to support the production process efficiency. This theoretical considerations supported by research in business practice, Authors presented in the publication (Koliński & Śliwczyński, 2015).

It needs to be borne in mind that production controlling concentrates its attention mainly on an operational level. As production controlling on an operational level is closely connected with production logistics and the flow of materials, one needs to take into consideration its role in achieving the following goals (Śliwczyński, 2007, p. 96):

- maintaining the earlier established level of customer service (sales, finished goods store),
- obtaining the lowest total costs of production (minimum level of funds lock-up, costs of changing production plans),
- obtaining the highest efficiency of production and logistics resources engaged in a production process,
- maintaining a reasonable level of supplies in a production process which ensures fluency and planned realization of production processes,
- maintaining stability of production plans and effective production as well as steady charge of production and logistic resources,
- elimination of bottlenecks in a production process.

Authors direction of further research is to compare the analyzes of business practice in Poland, with similar cases abroad. Conducted research will focus on standardized evaluation methods of the entire supply chain efficiency.

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<sup>1</sup> Having regard to subjects discussed in this manuscript are presented only general principles of economic efficiency and operational efficiency. Full analysis of within both ranges is presented in publications: (Koliński, 2013) (Koliński & Koliński 2013) (Koliński, Śliwczyński, Golińska, 2014).

<sup>2</sup> More on this topic (Koliński & Śliwczyński, 2015).

<sup>3</sup> The project *Science closer to business, business closer to science*, no POKL.08.02.01-30-018 / 10 was co-financed by the European Social Fund under Measure 8.2 Transfer of knowledge, Priority VIII - Regional Human Economy, Sub-measure 8.2.1 Support for co-operation between science and business, Human Capital Operational Programme.

<sup>4</sup> The results of preliminary studies have been published in (Fajfer, Koliński & Kolińska, 2013).