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A Model for Analyzing and Measuring the Performance of Industrial Enterprises

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Abstract

This research has attempted to use tool for action plan selection (TAPS) software, analytic hierarchy process (AHP) software and to use new developed software for defining performance indicators and how it could be used by managers to construct a performance measurement system. In this research, we used a process model of the organization, suitable for displaying a combination of input, process and output measures. Besides, new software for data collection, analysis and visualization of key performance indicators and their impact on the performance of the firm performance is developed. The empirical part of study is based on thirty interviews from ten case manufacturing and service organizations.

Key words: *analytic hierarchy process software, firm performance, key indicators measurement,*

1. INTRODUCTION

Organizational systems-enterprises are the most complex entities composed of many components. Management of the organizational systems is a challenge that relates to strategies, synergy, synchronization and integration of parts of the organization in order to achieve the set goals [1]. Management structure of today's business systems want an organization that is flexible enough to adapt quickly to market changes, able to be ahead of competitors, innovative enough to keep its products and services, capable of providing customer services and maximum quality [2]. Performance measurement is a concept that allows the coordination of component parts of complex organizations. Organization that understands and is capable to use the frameworks and methods for measuring performance in the management of its strategies, systems and processes have the ability to achieve competitive advantages [1]. Performance, in this context, simply can be understood as the ability of organization to achieve its goals [3]. Key performance indicators (KPI) are variables that, observed together, provide a meaningful, concise,

general picture of the organizational performance and its processes and are used for reporting about the progress towards achieving the set goals and at the same time reflect the critical success factors [4]. Briefly, the key performance indicators (KPI) are a set of measures focused on those aspects of the organizational performance that are most critical for the current and future success of the organization [5]. Key performance indicators (KPI) are variables that, observed together, provide a meaningful, concise, general picture of the organizational performance and its processes and are used for reporting about the progress towards achieving the set goals and at the same time reflect the critical success factors [4]. Briefly, the key performance indicators (KPI) are a set of measures focused on those aspects of the organizational performance that are most critical for the current and future success of the organization [5]. In the last two decades, academics and researchers in practice have developed performance measurement systems (PMS) including financial and non-financial measures. Many organisations place PMS at the top of their agends and generally implement PMS to: (1) monitor productivity, (2) communicate strategy, (3)

reduce costs, (4) review their business strategy, (5) control operations [6]. The most popular frameworks to assess firm performance are the balanced scorecard [7], the prism [8] and performance pyramid [9]. Positive effects of PMS have been discussed in a number of published studies, but many researches have argued that PMS also have negative effect on organisations [10]; [6]. Negative effects and a constant need for improvement PMS are the main reasons for the implementation of the presented research. In this study examines the possibility of using advanced software tools to measure the performance of the organization and as a support to managers in making decisions related to the improvement of business processes and the successful achievement of the goals and strategies of listed companies. There is also developed new software that provides collection, processing, analysis of key performance indicators, and displays their influence on the organizational performance.

2. THEORETICAL BACKGROUND

Recommendations for design and development performance measurement frameworks and systems generally relate to strategies, objectives, organizational and functional areas of the company, multi-criteria analysis, data gathering, reporting performance data, customers, stakeholders, etc. [11]. Performance measurement system is a set of measures that are used to quantify the efficiency and effectiveness of action [12]

Lockamy [13] has proposed for theoretical PMS models for the dimensions of cost, quality, lead time and delivery based upon research into the linkages between operational and strategic PM systems. Lynch and Cross [9] proposed the structured Performance Pyramid, which take into account a hierarchical view of business performance measurement. Rouse and Putterill [14] have developed the structural integrated performance measurement framework, which attempts an integration of number of structural frameworks. The balanced scorecard framework [7] is based upon four perspective: financial perspective, customer perspective, internal business perspective and learning and growth perspective.

Tan and Platt [15] developed tool for action plan selection (TAPS) that is to find the input and system variables required in order to achieve a given combination of output variable requirements. TAPS software tool enable managers to build an input/process/output performance model and has attempted to develop and test empirically an in/process indicative scorecard that will be useful to practicing managers attempt to achieve business [16].

KPIs are used for performance measuring and achieving the set goals, and to reflect the critical success factors [17]. Muchiri, Pintelon, Gelders and Martin [18] believe that performance measurement is a fundamental principle of management considering that performance measures provide an important link between strategy and management activities. In this

research will be used software tools TAPS and AHP which help managers in making strategic decisions.

3. OBJECTIVES AND HYPOTHESES

The research problem is defining KPIs of industrial companies and analyzing their impact on the performance and decision making, as well as the possibility of applying the analysis of the impact KPIs using appropriate software tools in management decision-making, where the KPIs are non-financial parameters.

Hypothesis in accordance with the aim and subject of the research can be defined as follows: (H-1) with a high degree of certainty can be argued that the process efficiency and effectiveness of organizations have a positive impact on reducing the total cost of industrial enterprises and (H-2) reduction of total costs affect the overall performance of industrial enterprises.

4. METHODOLOGY

The research will be conducted with the creation of the proposed method, and basis for its creation is the input-process-output-outcome model (Spitzer, 2007). In addition to helping in identifying key measures and defining predictions regarding the effectiveness and efficiency of the system, this model also provides more opportunities for performance analysis using produced software tool. The model which is also analyzed by creating of the proposed method is Connectance Model [19], [20] that is intended for the management of production. The model contains over two hundred variables and shows how changes in each of them affect the change of any variable that is associated with it.

Proposed new tool includes a definition of industrial enterprise goal, defining four functional areas as business sectors within the industrial enterprises, defining sixty key performance indicators-KPIs, fifteen within each functional area, conducting a survey based on Likert-type to provide the impact assessment of the sector and KPIs on defined goal of industrial enterprises, the statistical analysis of the results of the survey method, data processing in programs TAPS and AHP, as well as the development of new method proposed for the analysis of KPIs in software LabView. An innovative method includes pre-defined sixty KPIs in four sectors, with KPIs analyzed for each month during the year in industrial enterprises and measures their importance and value in four areas: effectiveness, efficiency, cost reduction and performance of industrial enterprise.

The performance analysis will be made within twenty industrial companies operating in the Republic of Serbia, in different branches of industry. The survey was conducted through interviews and surveys of senior management, middle management and team leaders of twenty companies of which there were ten domestic and ten foreign. Analyzed companies are operating in different industries that include manufacturing and services, of which ten industrial enterprises are selected and further analyzed in accordance with the established hypothesis.

5. RESEARCH

The research will be conducted on the sample of ten enterprises, of which six are international industrial companies concerned with production in different countries, and also in Serbia, and four companies concerned with providing services. Within four areas can be defined key performance indicators – KPIs [21],

[22], [23] and determine the influence of each indicator to achieve the goal of industrial enterprises. Due to the fact that the effectiveness and efficiency have impact to the reduction of costs, KPIs are divided into four functional areas as it is shown in Table 1.

Table 1. KPIs in four functional areas of industrial enterprises

KPIs in Marketing and Sales (11)	KPIs in Logistics and Manufacturing (12)	KPIs in Finance and Accounting (13)	KPIs in Human Resources (14)
The share of sell orders executed at the time (111) -efficiency	Ratio of realized orders and deliveries (121) - efficiency	Return on investment (131) -effectiveness	The efficiency of employees (141) – efficiency
Customer satisfaction index (112) -efficiency	Scarp rate (122) – neutrally	Inventory turnover ratio (132) -efficiency	Professional expertise of employees (142) – effectiveness
Index of number of new customers during the period (113) -neutrally	Overall efficiency of technological systems (123) -efficiency	Turnover ration of total assets (133) -efficiency	Motivation of employees (143) –efficiency
The index of quality of sold products (114) - efficiency	Preparatory - final time (124) -neutrally	Profit per product (134) - effectiveness	An effective business collaboration within the company (144) efficiency
Index of realization of contacts with customers (115) -efficiency	Quality of transport (125) -effectiveness	Net income (135) - effectiveness	Intellectual capital (145) –effectiveness
Time from investment to cash collection (116) - efficiency	Low transport costs (126) -effectiveness	Low salaries (136) - neutrally	Innovations from the employees (146) – neutrally
Company's reputation on the market (117) - effectiveness	Defects per million opportunities (127) - efficiency	Low level of investment (137) -neutrally	Education of employees (147) –neutrally
Reducing the number of customers (clients) (118) -neutrally	The percentage of damaged goods after delivery (128) neutrally	Liquidity index (138) - efficiency	Know- how (148) – neutrally
The attractiveness of products to potential customers(119) neutrally	Reliability of logistical support (129) - effectiveness	Return on equity (139) - effectiveness	Corporate culture (149) –neutrally
Recognition of the company's brands on the market (1110) - effectiveness	Mean time between failures (1210) -neutrally	Revenue per employee (1310) -neutrally	Competent external partners (1410) – efficiency
Percentage of saved customers in the last 3 years (1111) - neutrally	The time required for inventory turnover (1211) -efficiency	Return on investment (1311) -efficiency	Average employees professional experience of the (1411) –neutrally
Image of the company on the market (1112) - effectiveness	The overall efficiency of equipment (1212) – efficiency	Profit per unit (1312) - efficiency	Patents and licenses (1412) -effectiveness
Customers loyalty to the company (1113) - effectiveness	Average costs of production items (1213) -neutrally	Income taxes (1313) - neutrally	Design rights (1413) – effectiveness
The growth of the total number of customers (users) (1114) -neutrally	Reduction of costs of new product development (1214) - effectiveness	The average salary per employee (1314) - neutrally	Entrepreneurial employees (1414) – efficiency
The growth of the market share of the company (1115) - effectiveness	Reduction of imported materials (1215) - effectiveness	Earning per project (1315) -effectiveness	Professional qualifications of employees (1415) – effectiveness

Research was conducted in ten industrial enterprises on the basis of a questionnaire to senior management that analyzed the overall possibilities for efficient

production with minimum cost (1) and middle managers and team leaders in four sectors: Marketing and Sales (11), Logistics and Production (12), Finance and

Accounting (13) and Human Resources (14). The analyze is making in TAPS, since it provides the ability to visually display connections with lines, as influences of KPIs to defined sectors and target, which are presented as circles, where in the upper part of the circle there is the label for the KPIs as indicated in the

table above, and in the lower part is the impact on the target with the value obtained by the survey. The results of the survey in the first company, worked in TAPS, are shown in Figure 1.

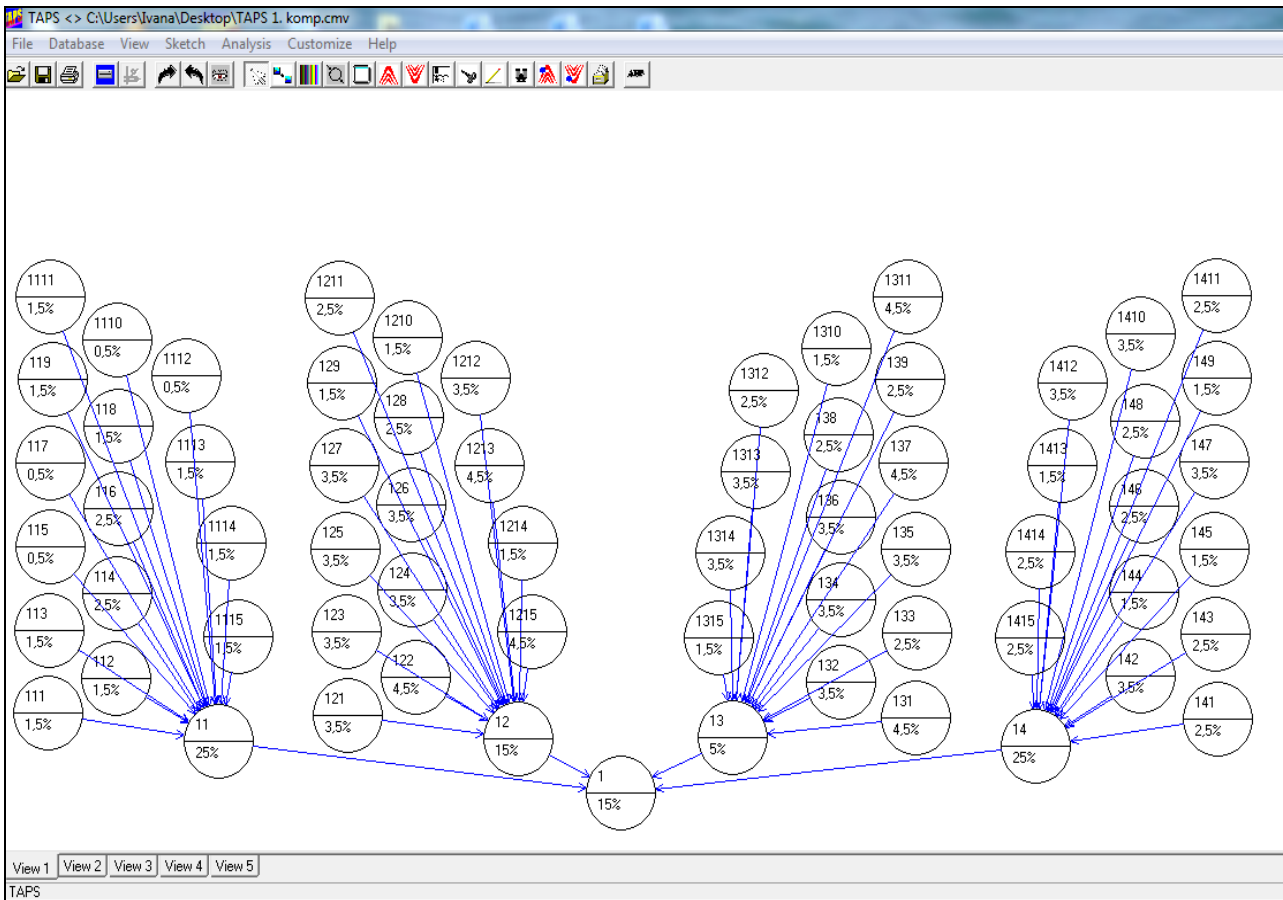


Figure 1. KPIs presented in the TAPS program for the first industrial enterprise

In the first industrial enterprise the most influential KPIs belong to sector 14, and their impact is 0.0013125. The most influential are the following KPIs: 142 - Professional expertise of employees – effectiveness, 147 - Education of employees - neutrally, 1410 - Competent external partners - efficiency. In the same way, the analysis of other companies is made, and the results confirm previous ranking KPIs. These results support H-1.

AHP method

Based on the results of the questionnaire relating to the impact of KPIs to defined target, it is possible to define alternatives in AHP program and analyze which alternative is the most important to the impact of selected KPIs which are defined as criteria.

An example which is shown in Figure 2 refers to the analysis the first industrial enterprise in four sectors and will be presented as the analysis of Marketing and Sales. The cycles represent objective, criteria and alternatives, with the label for the KPIs and sector, as indicated in the Table 1, with arrows which represent influence and values which represent importance of alternatives based on criteria.

Objective: Marketing and Sales (11), Alternatives: customers, selling, image

Criteria: 112 - Customer satisfaction index – efficiency, 117 - Company’s reputation on the market - effectiveness, 1112 - Image of the company on the market –effectiveness. The criteria contains KPIs which support H-1.

The result shows that the most important alternative is selling, while customers and image have the same result, lower in 0.0001 than for selling. Analysis of the most important alternative in the four sectors was made by comparing the following results: Sector 11: 0,3334 Selling, Sector 12: 0,3334 Reliability, Sector 13: 0,3335 Income, Sector 14: 0,3334 Rights. The most important alternative is Income.

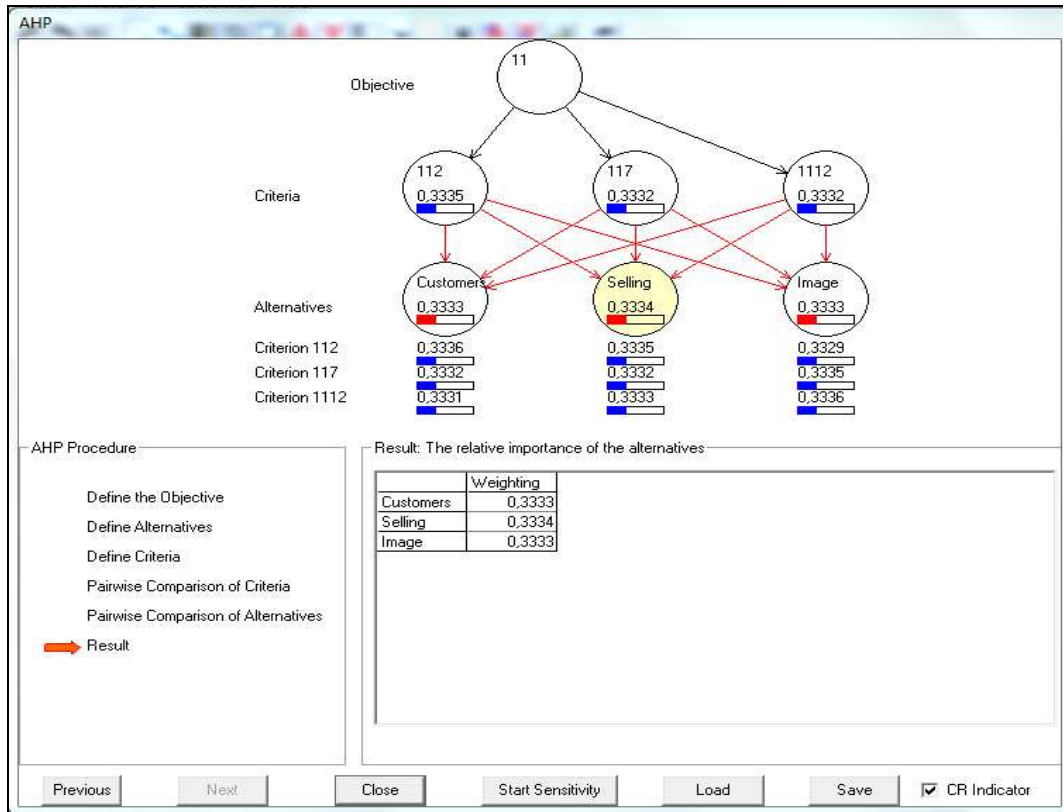


Figure 2. - AHP analysis

The median for each sector and each KPI based on the results of the survey of eight industrial enterprises is calculated by statistical data processing method. According to the assessment, all sectors and KPIs are divided into three groups: little significant (marks 1-2), medium significant (marks 2,5-3,5) and very significant (marks 4-5).

According to the median sector that has the most impact is: Marketing and Sales – 11 (mark 3.00). From the above mentioned KPIs within the Marketing and Sales sector, to assess the median the most influential is: Time from investment to cash collection - 116 - efficiency (mark 5.00). According to the analysis of the median and the impact of the sector and individual KPIs, the KPI is considered the most influential of the

defined goal - effective and efficient production with minimum cost, and results support H-1.

6. FINDINGS

Considering that the measurement of performance in addition to the many benefits for industrial enterprise has also disadvantages in terms of increased bureaucracy and investments, as help, a new method of LabView software is created and includes sixty KPIs above mentioned. Using this method, KPIs are analyzed in industrial enterprises during a year with measuring the importance and value of each KPI in four areas: effectiveness, efficiency, cost reduction and performance of industrial enterprises. Figure 3 shows the results of all KPIs within the sector.

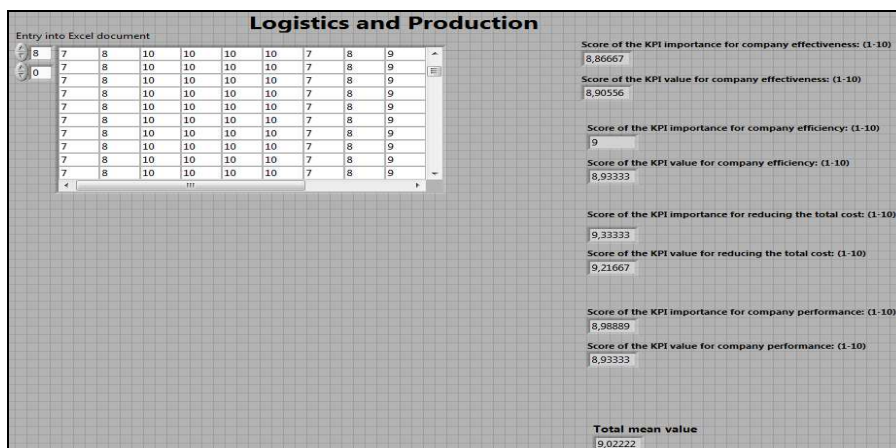


Figure 3. Analyse for each sector

Middle management and team leaders within each functional area evaluate KPIs for each month according to the importance and value for all four areas, according to which the program calculates and shows the diagram for each sector and overall industrial enterprise. In this analysis will be presented monitoring and measurement of KPIs within the sector for Logistics and Production. Based on the analysis of the assessment KPIs for twelve months, the program calculates and graphically displays the mean value of all KPIs within the sector.

Score of the KPI:

KPI importance for company effectiveness – 8, 86667

KPI value for company effectiveness – 8, 90556

KPI importance for company efficiency – 9

KPI value for company efficiency – 8, 93333

KPI importance for reducing the total cost – 9, 33333

KPI value for reducing the total cost – 9, 21667

KPI importance for company performance – 8, 98889

KPI value for company performance – 8, 93333

Total mean value – 9, 02222.

Figure 4 graphically displays the mean importance score based on the average size of all fifteen KPIs in the sector for Logistics and Production for effectiveness, efficiency, reduce overall costs and performance of industrial enterprises.

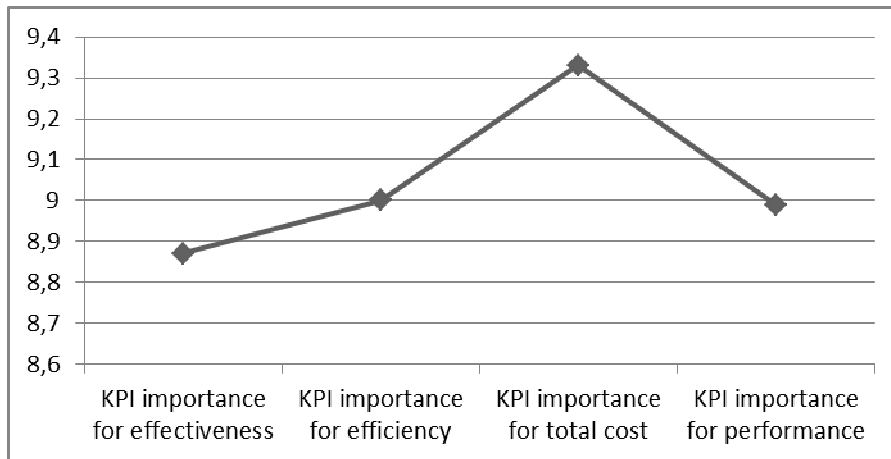


Figure 4. Graphical display of mean importance score of KPIs in the sector of Logistics and Production

In a similar way, there can be graphically displayed the mean value score based on the average size of all the KPIs in the sector for Logistics and Production for effectiveness, efficiency, reduce overall costs and performance of industrial enterprises.

Based on the analysis of average values can be concluded that in the sector for Logistics and Production according to mean importance score the highest importance and the highest value of KPIs is for reducing overall costs. In addition, the average grade of the importance and value of effectiveness, efficiency and impact on performance also have high scores, which supports H-1, and from which it can be concluded that management in this sector should pay the most attention to the possibility of reducing the total cost, but also to the other three areas. Since reduction of total costs mostly affects the overall performance, the result also supports H-2.

7. CONCLUSION

In this research the focus was on investigating the impact of process efficiency and organization effectiveness to the cost reduction. The research largely achieved the objectives that determine the KPI has a value for the organization and can influence development strategies and help in organizing efficient production with minimum cost.

Based on the research and use of various methods, hypotheses are proven as follows:

H-1: Analysis of the data obtained from the survey in TAPS give the result that four of the nine most influential KPIs for reducing the total cost of the industrial enterprises related to efficiency and three to effectiveness, while the median statistical analysis obtained result that one of two most influential KPIs refers to efficiency and the other to effectiveness. The analysis with AHP method gives the result that one of the three KPIs relates to efficiency and two to effectiveness, and obtained the result that the most important alternatives which reduce the total cost of the industrial enterprises is income. Based on analysis using innovative tool in LabView software, five of fifteen KPIs in the sector of Logistics and Production relate to efficiency and five to effectiveness, and based on the survey the obtained result shows that their greatest impact is on reducing the total cost, from which it follows that with a high degree of confidence can contend that efficiency and effectiveness of processes have a positive impact on reducing the total cost of the industrial enterprise.

H-2: Based on the analysis of fifteen KPIs during one year with an innovative tool in LabView software, obtained result shows that the average of assessed values for the KPIs is that their importance and value are approximately equal for the effectiveness, efficiency and overall performance, while the importance and value for reduction of total costs is greater, which means that based on the analysis of KPIs best opportunity for business improvement is to reduce costs, from which we can conclude that the reduction of

total costs affects the overall performance of industrial enterprise. Conclusion regarding to the hypothesis was confirmed only in terms of the questionnaire, because the whole study has not been completed at this moment. For further research is needed to explore the relationship between effectiveness, efficiency and costs, as well as the impact of effectiveness and efficiency on cost reduction and improvement of overall performance of industrial enterprise. Further confirmation of the hypothesis will be presented after completing mathematical tests.

8. ACKNOWLEDGEMENT

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Model za analizu i merenje performansi industrijskih preduzeća

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Rezime:

Ovo istraživanje pokušava da koristi softverski alat za izbor akcionog plana (TAPS), analitički hijerarhijski procesni softver (AHP) i upotrebu novih razvojnih softvera za definisanje indikatora performansi i načina na koji mogu da ih koriste menadžeri kako bi strukturisali sistem merenja performansi. U ovom istraživanju koristili smo procesni model organizacije koji je pogodan za prikazivanje kombinacije mera ulaza, procesa i izlaza. Pored toga, razvijen je novi softver za sakupljanje podataka, analizu i vizualizaciju indikatora ključnih performansi i njihov uticaj na performanse kompanije. Empirijski deo studije se zasniva na trideset intervjuja iz deset slučajeva proizvodnih i uslužnih organizacija.

Ključne reči: analitički hijerarhijski procesni softver, performanse kompanije, ključni indikatori merenja