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BUSINESS PROCESSES IMPROVEMENT IN E-SUPPLY CHAINS

Dragana Rejman Petrovic*

University of Kragujevac, Faculty of Economics, Kragujevac, The Republic of Serbia

The development of a model to improve business processes in e-supply chains involves the use of a process approach to and a methodology for information systems development and includes the definition of the requirement, logical key process modeling with the defined information flow within the logical subsystem, logical data modeling, the logical network and data distribution modeling, and the logical interface modeling in order to meet different users´ needs. In doing so, a variety of methods and techniques for the different development stages of management information systems are used, namely: the business process management, the business process performance management and the analytic hierarchy process as a method for multiple-criteria decision making. This paper analyzes business processes and different types of supply chains in the automotive industry, as the representative of complex systems. Based on the selected key business processes and key performance indicators of business processes, the analytic hierarchy process model is developed, followed by their optimization. The result is the management information system model intended to improve the key business processes in e-supply chains. The research results show that the performance improvement of business processes in e-supply chains, the application of the model to improve the key business processes and the application of Web-based information and communication solutions affect the efficiency and quality of e-supply chains.

Keywords: supply chains, business processes, performance measurement, management information systems.

JEL Classification: M10, M15, M21

INTRODUCTION

The supply chain is not only focused on specific functions in organizations, such as procurement, production and delivery, but also on the improvement of the system performance in the internal and the external environments. In the competitive environment of the 21st century, organizations in the supply chain need to ensure efficiency, a high level of service, a fast response and a high quality of products and services. Supply chain management assumes the holistic and the strategic approaches to the processes of demand, production, procurement and logistics. The supply chain concept has substantially changed the nature of the organization. Control is no longer based on the direct control of the business processes of individual organizations, but rather on the control

*Correspodence to: D. Rejman Petrovic, University of Kragujevac, Faculty of Economics, Dj. Pucara 3, 34000 Kragujevac, The Republic of Serbia; e-mail: rejman@kg.ac.rs

of all the processes among integrated organizations as members of the supply chain. Coordination among organizations in the supply chain is the key to its effective implementation. It is necessary for organizations to become aware of their role and activities in the supply chain and the fact that their performance affects the performance of the other members of the supply chain. This means that organizations need to manage the supply chain performance to achieve a competitive advantage.

The present work shows the model developed for measuring the performance of the key business processes in e-supply chains, which provides for the improved efficiency and quality of the entire supply chain. The development of the model for measuring the performance of the key business process of the e-supply chain started from the concept of quality management in supply chains. The process of quality management in supply chains involves the measurement, analysis and continuous improvement of products, services and business processes, as well as the coordination and integration of the business processes of all member organizations in the supply chain. The developed performance measurement model provides a structured approach to quality in supply chains, which includes the required and defined quality level of the chain network design, the quality of procurement, sales and logistics processes, as well as the use of resource planning systems in organizations. The quality and efficiency of each business process is measured based on the analyzed, selected and defined key performance indicators, which have different relative importance in different types of supply chains.

The developed model was tested in the member organizations of the automotive industry's supply chains and included the organization-supplier-customer sequence, which recurs in the context of the supply chain, because each organization in the supply chain has its own suppliers and customers. Starting from the above facts and assumptions, the developed model becomes applicable to each member in the supply chain.

In the new approach, the author focuses on calculating the key performance indicators, identifying gaps, depending on the actual and target values of the key performance indicators belonging to a particular performance attribute (quality - Q, costs - C, delivery - D and flexibility - F), as well as on the calculation of the overall performance of different types of supply chains (efficient, lean, fast and hybrid) as a result of the integrated key performance indicators and their relative importance in relation to the particular type of the supply chain. In fact, assessing all the key business processes in the supply chain, by using the selected and defined key performance indicators and their different priorities, leads to an overall supply chain performance measurement. This approach allows the management, both at the level of the supplier-organization-customer sequence and the level of original equipment manufacturers (OEM), as the supply chain owners, to track, analyze and identify the critical spots and links in the supply chain, as well as various simulations in this regard, in order to improve business processes in e-supply chains.

The research subject presented in this paper is the business processes in e-supply chains and the ways to enhance them, as well as the improvement of the overall network of business processes.

The objective is to develop a model for improving the performance of e-supply chains by improving the performance of the key business processes, supported by information and communication solutions.

Based on the determined research subject and objective, the paper sets up the following hypotheses:

H1: The modeling of business processes and performance can define the key business processes in e-supply chains;

H2: Using the Web-based information and communication solutions can improve the performance of business processes in e-supply chains.

H3: Improving the performance of the key business processes affects the efficiency and quality of e-supply chains.

To develop a management information system model to measure the performance of business processes in e-supply chains, the methods supporting individual or multiple stages in the lifecycle of the information system development are used, such as: the system development life cycle (SDLC), the business system planning (BSP), the structured systems analysis (SSA), the structured systems analysis and design method (SSADM), the object-oriented analysis (OOA), the data flow diagram (DFD), the entity relationship model (ERM). In order to evaluate and rank supply chains, the multiple-criteria decision-making method is used - the Analytic Hierarchy Process (AHP). This results in the improvement of the data model, in terms of the applied AHP model requirements.

The paper consists of five sections. After the Introduction, the importance of the performance measurement of business processes in supply chains and the link between the priorities of the different types of performance measures and certain types of the supply chain are pointed out. The third section presents the planning and development of information systems to support and improve business processes in e-supply chains. The fourth section gives the key research results. The fifth section summarizes the concluding remarks, indicates the theoretical-methodological and practical contribution of the paper and defines possible directions for further research.

MEASURING BUSINESS PROCESS PERFORMANCE IN SUPPLY CHAINS

With the increasing number of inputs, as well as an increase in the volume of control and the increasing complexity of operations, data management (DM) and data use are becoming more complex. Events produce data and each piece of such data is a potential indicator, whereas just a few indicators are considered as the key performance indicators (KPI) (Karadgi, 2014)

All members of the supply chain, upstream and downstream, are the participants that have an impact on the supply chain performance (e.g. quality, delivery, the cost, flexibility). The need to determine the appropriate type of the supply chain performance measure is vital, as it will, and as such, influences decision making. For example, if a measure does not provide accurate and relevant information on the process to be measured, it can lead to wrong decisions followed by counterproductive actions. A large number of studies emphasize the need for the right type of performance measures in supply chains (Otto & Kotzab, 2001; Shepherd & Günter, 2006; Vereecke & Muylle, 2006; Koh, Demirbag, Bayuraktar, Tatoglu, & Zaim, 2007; Bai & Sarkis, 2012; Bai, Sarkis, Wei & Koh, 2012; Cabral, Grilo & Cruz-Machado, 2012; Gimenez & Tachizawa, 2012; Genovese, Lenny Koh, Kumar & Tripathi, 2014). The results obtained through the conducting of these studies indicate various selected, defined and tested performance measures used among organizations.

The area of the supply chain performance has been widely covered in the literature (Holmberg, 2000; Lambert & Pohlen, 2001; Landeghem van & Persoons, 2001; Tracey & Tan, 2001; Petroni & d Panciroli, 2002; Chan & Qi, 2003; Gunasekaran, Patel & McGaughey, 2004; Morgan, 2004). These studies highlight the need for measuring the effectiveness of an integrated supply chain.

A. Petroni and B. Panciroli (2002) claim that customers typically retain the suppliers that achieve the highest overall performance, expressed through the price, quality, production flexibility and the delivery time. A. De Toni, G. Nassimbeni and S. Tonchia (1994) argue that an effective supply chain depends on achieving a high level of performance in terms of the cost, the quality and the lead time. R. H. Hayes and S. C. Wheelwright (1984) were the first to introduce the methods for achieving an operational strategy by using the four dimensions that the organization chooses in order to compete within the target market, such as quality, the price, flexibility and delivery. Their original formulation was applicable to all functions.

D. M. Lambert and R. L. Pohlen (2001) argue that a well-designed measurement system in the supply

chain can lead to a competitive advantage through the differentiation of services and lower costs. They also believe that the implementation of the supply chain strategy requires the metrics that balances performance and the goals of the other members in the supply chain. The supply chain performance can be regarded as a system of measures, such as quality, delivery, flexibility and cost/price. The traditional performance measures, such as profitability, are less relevant for measuring the performance of the supply chain.

Establishing a measurement system requires the knowledge of the processes within the organization and between customers and suppliers. In order to generate this knowledge, the organization has to decide which performance measures will be taken into consideration. I. Robson (2004) states that, "without knowing the exact circumstances under which the system of measuring will lead or not lead to performance improvement, it is difficult to justify the additional cost of implementing the system of measurement".

The performance measurement system in the supply chain consists of a set of parameters that can completely describe logistics and production performance in the entire supply chain, both from the perspective of end customers and any other member in the supply chain. However, there are a number of performance measures and attributes in the supply chain that can be evaluated. The most commonly used in practice, as well as the most cited in the research, are the following measure attributes: quality, delivery, cost/price and flexibility.

Given the fact that there are different types of supply chains and that supply chains have different characteristics, they as such require individual attention in order to achieve the optimal performance of the supply chain (Christopher & Towill, 2000; Mason & Cole, 2002; Saad & Patel 2006; Christopher, Peck & Towill, 2006). Certain supply chain performance measures will be prioritized, depending on the type of the supply chain.

In an efficient supply chain, the primary performance measures are costs, such as total costs, ranging from the supplier, via the internal supply chain, to the customer, i.e. all kinds of costs that have an impact on production costs. An agile supply chain reacting quickly to market demands has a shorter lead time, so that in this type of the supply chain the primary measure is delivery, only to be also followed by the flexibility (mix) of production and the product quality. A shorter lead time from order to delivery is yet another important measure in the lean supply chain. The hybrid supply chain is focused on shortening time without creating additional costs in order to adapt to customers´ requirements, so that the primary performance measures are delivery, flexibility and quality.

This establishes a link between the priorities of different types of performance measures in the supply chain and the supply chain of a certain type, which is the basis for developing a model for improving the performance of business processes in e-supply chains.

THE PLANNING AND DEVELOPMENT OF THE INFORMATION SYSTEM FOR SUPPORTING AND IMPROVING BUSINESS PROCESSES IN E-SUPPLY CHAINS

In the process of planning and developing information systems in order to support and improve business processes in e-supply chains, the following methods are used: the business system planning (BSP) method, the structured system analysis (SSA) method, the database management systems (DBMS) method (Arsovski, 2013) and the analytic hierarchy process (AHP), as a method for multiple-criteria decision making (Saaty, 2010).

By using the BSP method, based on stakeholders´ requirements and needs for the performance improvement of business processes in e-supply chains, the following is achieved:

- organization and the supply chain business objectives are modelled, along with the objectives of the information system, in order to improve

the performance of business processes in e-supply chains,

- the key business processes in the organization and supply chains are identified, as well as the procedures and the guidelines regulating the method of the execution of processes and activities, authorities and responsibilities, terms, documentation, standards, reports for different levels of management and decision making, resources and so forth,
- a generic logical model of the key processes and data in order to support the information system is developed so as to improve the performance of business processes in e-supply chains.

Using the SSA method, with the help of the ERwin and BPwin software tools, a detailed logical process model, a detailed logical data model and an interface model are developed.

Using the database management system, the logical data model is transformed into a database, thus achieving data consistency, eliminating data redundancy and ensuring data protection from unauthorized access.

By using the AHP method, a model for the evaluation of supply chains and their ranking according to the selected criteria is developed in order to, based on the supply chain performance, see the ranking of the supply chain and decide where reaction is needed to improve its performance.

Model of Stakeholders′ Requirements for the Management of the Performance Business Processes in e-Supply Chains

ZIn order to develop a model for the management information system for measuring and improving the performance of business processes in e-supply chains, stakeholders′ requirements for the improving of the performance of the business processes in e-supply chains are defined in the first place.

Requirement modeling is the basis for defining an approach to and a strategy for the development of the information system, so that in this process the collection of requirements and meeting the user′s needs are a very important activity. The modeling process requires an analysis of stakeholders′ different requirements.

The process of the analysis and recording of such requirements includes the identification of all requirements aimed at improving the key processes in the supply chain, which in any way affect or will be affected by the future system. Due to various stakeholders′ different requirements, it is necessary to categorize them.

Stakeholders may be internal and external. Internal stakeholders are an organization′s managers, employees and owners. External stakeholders are OEM, customers, suppliers, business partners, banks, as well as the community, government agencies, various non-governmental organizations and so on.

In order to define and analyze stakeholders′ requirements, the author applies interviews, analyzes work done in a specific environment and studies the documentation. In order to develop the requirement model, the following stakeholders are selected: the management, the owners, suppliers, customers and OEM.

In terms of improving the performance of the business processes in e-supply chains, the requirements and needs coming from the management of the organization refer to the efficiency of the information system in respect of the automated and efficient generation of different types of reports on the key performance indicators for different business processes. Also, the management have their own needs and requirements for the use of the method for conducting a multiple-criteria analysis and optimization, which in this case is the AHP model, given the fact that decisions made by the management are complex and usually inclusive of multiple conflicting criteria. This enables managers, in the case of the occurrence of complex problems with a number of alternative criteria, to relatively easily establish relationships between the influencing factors, recognize their explicit or relative influence and importance in real conditions and determine the dominance of one factor over another. The requirements and needs of the management are formulated as a possibility of:

- monitoring the key business processes, which in this case are procurement, sales and logistics;
- measuring and analyzing their key performance indicators at different time intervals;
- measuring and analyzing the overall performance of different types of supply chains at various time intervals, and
- evaluating, ranking and comparing different types of supply chains.

For the owners, the selected requirements and needs for information relate to the amount of return on the invested capital and a long-term sustainable capital increase, the sales growth percentage, the percentage of a reduction of or an increase in the cost of transportation and the supply chain optimization.

For suppliers, the chosen requirements and needs relate to:

- the defined product/service delivery specifications,
- electronic data interchange, or EDI order receipt (EDI - Electronic Data Interchange), forecasting the ability for a period of six months,
- exchange of information on the actual key performance indicators of the business processes and their target values,
- information about the weights of the key performance indicators for the appropriate type of the supply chain.

For customers, the chosen requirements and needs relate to: information about the product quality, the conformity of the delivery quality, the deadlines, the acceptability of the product price, the price/quality ratio, the availability of the required amount of the product/number of the provided services, the availability of information on products/services, the availability of information on the status of orders, the way of dealing with complaints, the exchange of information on the generated key performance indicators of the business processes and their target values, and information on the weights of the key performance indicators for the appropriate type of the supply chain. Customers articulate their requirements through the 100/0/30 principle, which means that the organization, as the supplier, must ensure 100% on-time delivery, with 0 ppm (non-conforming parts per million produced) no later than 30 days after the launch of production. In order to achieve this, the organization must impose such requirements on its suppliers in order to meet customer requirements.

For OEM as the owner of the supply chain, the chosen requirements and needs relate to access to information about all supply-chain member organizations′ required key performance indicators in the defined form.

The model of stakeholders′ requirements for the performance management of business processes in the e-supply chain is shown in Figure 1.

The analysis of user requirements is carried out for all the three management levels: strategic, tactical and operational. Based on the specification of requirements for information at all management levels, the systematization and specification of information needs per business processes is carried out, based on which interface modeling for management purposes is performed. Given the different characteristics of tasks and different information for each management level, the definition and analysis of user requirements is based on the fact that different management and decision-making levels set specific requirements in terms of the volume and type of information that should be provided to them. Diversity refers to the necessary indicators and information, the period of the submission of the required information and the form of information, as accounted for in Table 1.

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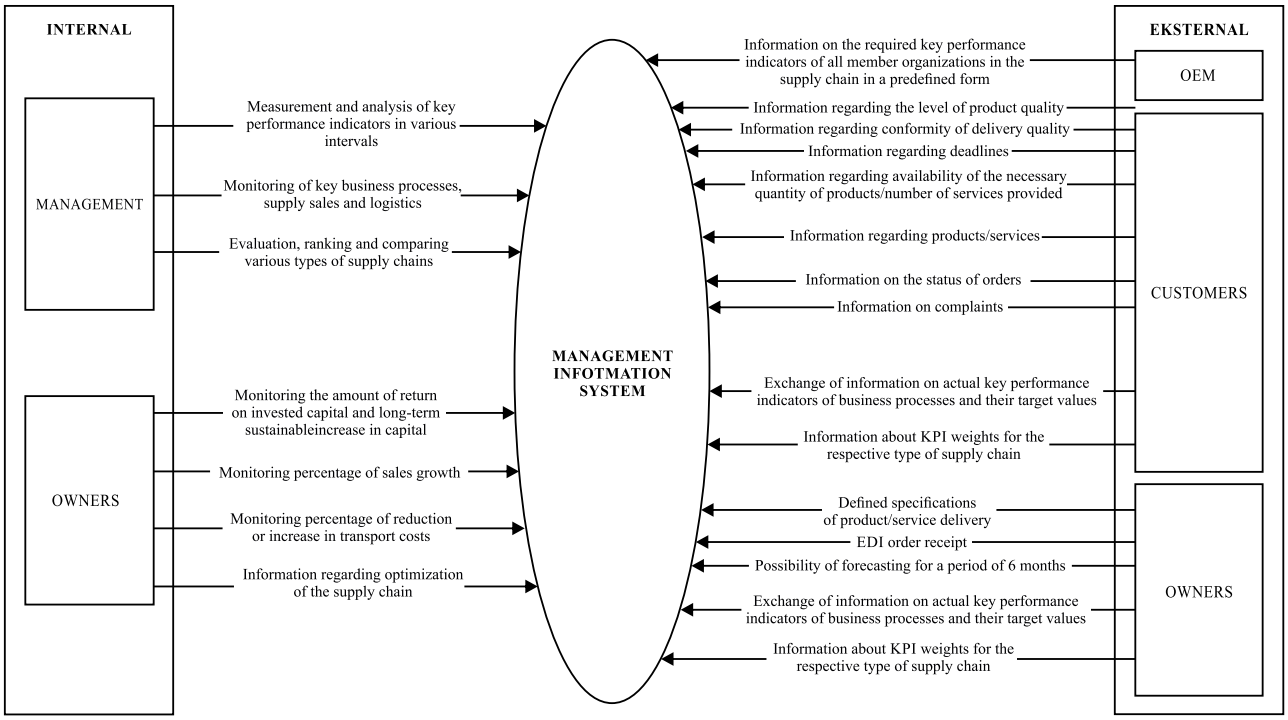

Figure 1 The model of stakeholders' requirements for the performance management of business processes in the e-supply chain

Source: Author

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Beside the usual and widespread practice regarding management requirements, there is a tendency for new management requirements in terms of the evaluation and ranking of the supply chain, so that they are associated with and integrated into a developed and presented model for the improvement of business processes in e-supply chains, which is a step forward of this management information system.

Process Modeling in e-Supply Chains

For planning and developing an information system, the key phase is the analysis, the selection of the key processes and defining business processes. Accurately selected and defined business processes determine the quality of the

projected information system. In order for an information system to be independent of future organizational changes in the business system, it is necessary that it be based on processes rather than organizational units, i.e. business system functions. In addition, processes enable a better understanding and facilitate the analysis of the functioning of the business system.

Table 1 The systematization and specification of information needs per business processes

Level	Processes	Indicators	Time interval	Form
Strategic	Supply chain	Total ranking of identified types of supply chain Ranking of different types of supply chains KPI priorities according to types of supply chains Influence of change in relative importance of different criteria on the supply chain ranking Influence of change in priorities of individual KPI on the supply chain ranking Evaluation and ranking of suppliers depending on the type of the supply chain	Quinquennial, annually, and quarterly	Electronic and written report with Tables and graphs for all functions of the organization
	Procurement	% of the cost of procurement in net proceeds from sale (NPS)		
	Sale	Sales growth		
	Logistics	% of transport costs in net proceeds from sale		
Tactical	Procurement	Procurement costs Procurement by suppliers Complaints to suppliers Supplier OTD (On-time delivery) Supplier PPM (share of non-conforming parts per million produced) Supplier DMR (discrepant material report) Cost of poor quality of suppliers Assessment of suppliers	Quarterly and monthly	Electronic and written report with tables and graphs
	Sale	Realized sales Sale by customers Customer complaints OTD (On-time delivery) PPM (share of non-conforming parts per million produced) DMR (discrepant material report) Cost of poor quality Assessment of organization by the customer		
	Logistics	Total transport costs Regular and extraordinary transport costs Transport costs for each service provider Complaints by service Assessment of service provider		
Operational	Procurement	Supplier OTD (On-time delivery) Supplier PPM (share of non-conforming parts per million produced) DMR (discrepant material report) Cost of poor quality of suppliers	Weekly and daily	Electronic and written report with tables and graphs
	Sale	OTD (On-time delivery) Supplier PPM (share of non-conforming parts per million produced) DMR (discrepant material report) Cost of poor quality		
	Logistics	Total transport costs Transport costs inbound regular Transport costs inbound extraordinary Transport costs outbound regular Transport costs outbound extraordinary		

Source: Author

In order to model business processes in the e-supply chain, one should consider the supply chain as a whole, which implies the integration of very large and complex multidisciplinary dependent processes and information. Processes in the supply chain in the automotive industry begin with the procurement of resources, continue with the process of production, assembly, storage and transport, and end with the delivery of the finished product to the end customer.

In accordance with the subject of this research, referring to business processes in e-supply chains, identifying the ways to improve the network of business processes and developing models for improving the performance of business processes in e-supply chains, the supply chains of organizations operating in the automotive industry belonging to Tier 3 are analyzed.

Bearing in mind the defined and determined key performance indicators the basis for defining the structure of management information systems in order to improve the performance of business processes in e-supply chains lies in the processes of procurement, sales and logistics. Within each module, the subsystems for measuring performance are defined, which enables the organization's management to access information on actual key performance indicators for each business process. The modules can be administered alone, whereas the real power of the information system to measure the performance of business processes in e-supply chains lies in the synergy of integrated modules, because in this way it allows the integrated measurement of the supply chain performance.

The main task of the procurement process is to achieve the seven major goals: the right product/service, the right quantity, the right conditions, the right supplier, the right time, the right service and the right place, on the basis of which it can be concluded that it is the procurement process that ensures the continuity of the realization of all other processes in the organization. Also, a detailed analysis of the literature on the key performance indicators shows that the key measures to monitor the supply chain performance are the product quality (through quality conformity, quality reliability and the final product quality), delivery (the delivery time, delivery reliability, delivery frequency, delivery synchronization, the delivery speed), and transport costs (through a comparison of the actual delivery costs - inbound, and shipping costs - outbound, and their share in the total transport costs, as well as a comparison of regular and extraordinary inbound and outbound costs).

Since these measures describe performance across organizational boundaries and measure the performance of the entire supply chain, including links to suppliers and to customers, a prerequisite for the measurement and analysis of the key supply chain performance is the existence of an information system that tracks operations, primarily the processes of procurement, sale, transport and customer complaints, because such a system can automatically lead to the selected key performance indicators.

In order to measure the performance of the defined supply chain, the following key performance indicators of the product quality, delivery quality and transport are selected:

- supplier key performance indicators: supplier on-time delivery (SOTD), discrepant material report (SDMR), parts per million (SPPM), cost of poor quality (SCPQ), the cost of inbound transport (regular costs and extraordinary costs) and
- the key performance indicators of the organization to the customer: on-time delivery (COTD), discrepant material report (CDMR), parts per million (CPPM,) the cost of poor quality (CCPQ),the cost of outbound transport (regular and extraordinary costs).

In this way, the organization is able to monitor and measure performance associated with its supplier and its procurement process, and also monitor and measure its performance related to its sale process, which is actually a link with its customer's procurement process, thus, through the assessment of its delivery process, obtaining information about the performance of the customers' procurement process. This, in turn, makes it possible to measure, monitor and analyze the performance of the supplier-organization-customer sequence in the supply chain, resulting in the improvement of the performance of the business processes in the supply chain.

Modeling the Subsystem, the Key Processes and Data Classes

Based on the defined stakeholders′ requirements (the management, the owners, customers, suppliers and OEM), the business process mapping in e-supply chains and the model for the improvement of the business process, the modeling of the key processes in e-supply chains is carried out. In order to develop the process models, the following methods are used:

- the BSP method, whose outputs are defined logical subsystems and key processes and data classes, and
- the SSA method, whose outputs are decomposed data flow diagrams (the context, the root and the primitive function diagram).

On the basis of the formed data processes/classes matrix, the following logical subsystems are defined: the procurement subsystem (within it, the procurement contracting subsystem, the procurement planning subsystem, the procurement implementation subsystem, the performance measurement and evaluation of suppliers subsystem and the subsystem for measuring the performance of the procurement process), the sales subsystem (within it, the subsystem for measuring the performance of sales) and the logistics subsystem (within it, the subsystem for measuring the performance of the transport process).

Logical subsystems include data streams/data warehouse that the procurement, sales and logistics systems exchange internally with other subsystems in the organization, as well as externally, with business partners. Also, they include the corresponding key processes that generate, use and update certain documentation. The matrix shows only the new processes that improve the current situation and will, with the development of a new system, contribute to improving the performance of business processes in e-supply chains (Table 2).

In order to develop a system for measuring and improving the performance of business processes in supply chains, based on pre-defined procurement, sales and logistics processes, a level-based process hierarchy is defined, as well as the mutual dependence of the processes, with the help of the process/process matrix (Table 3).

For the purpose of developing a model to improve business processes in e-supply chains, the analysis focuses on the manufacturing organizations in the automotive industry that have introduced the ISO/TS 16949 standard, which guarantees operation after the process approach and the existence of well-kept business processes. For the organizations observed, the decomposition of the three key processes (procurement, sales and logistics) is performed, where the processes are subjected to decomposition to the level necessary for the analysis, implementation and measurement of the processes in the supply chain. To describe the unfolding of each process, with the present relations between the processes, the processes and the sources, the processes and the destinations, as well as the processes and the internal data warehouses, the data flow diagrams are used. The data flow diagram is formed through:

- the context diagram (the 0-th level),
- the medium-level diagram, and
- the primitive function diagrams at the lowest level, as shown in Figures 2, 3, 4 and 5.

The modeling of the business processes in the supply chain is controlled by the BPwin software tool for the modeling and analysis of complex business processes.

Data Modeling in e-Supply Chains

One of the important parts of the system analysis is the construction of a stable and complete data model in the observed business area. The organization uses hundreds of data types in its transactional processes. The data model is a means to achieve the logical interpretation of data in a particular area and allows one to understand the information content of such data. It can, therefore, be understood as a set of data structures and operations on these structures aimedat determining the logical database structure and the dynamic modeling of certain reality areas.

Table 2 Logical subsystems and the key processes and data classes in e-supply chains

Subsystem	Process \ Data classes	OTD trend	Supplier DMR list	Supplier PPM trend	Process Audit Report	Supplier assessment	DOH- Days on Hand List	Purchasing Report	Customer OTD trend	Customer DMR list	Customer PPM trend	Customer Process Audit report	Organization assessment by the customer	DOH of finished goods on customer demand	Transport Order	Invoice from courier company	Transport costs report
Supplier performance measurement	Supplier performance measurement - the quality of the delivery	C	C														
	Supplier performance measurement - the quality of the product			C													
	Supplier assessment	R	R	R	C	C											
The purchasing process performance measurement	Purchasing process performance measurement						C	C									
The sales process performance measurement	Organization OTD performance								C	C							
	Organization performance due to product quality										C						
	Organization assessment by the customer								R	R	R	C	C	C			
The logistics process performance measurement	Logistics process performance measurement														R	R	C

Source: Author

In the process of data modeling, one starts from the model of organization obtained in the phase of strategic information planning. A data model is generated through detailed process modeling, the analysis of data flows and documents and the identified needs for information important for the specific business area.

The data modeling procedure is carried out in three steps:

- the identification of all entity types on the basis of: the results of the modeling process, the results of the analysis of data flows, the flows and the content of documents, the results of the analysis of different applications, and the results of the analysis of the user´s requested information needs;
- the establishing of the links and the types of the links between entities, as well as the model presentation through the entity relationship diagram;

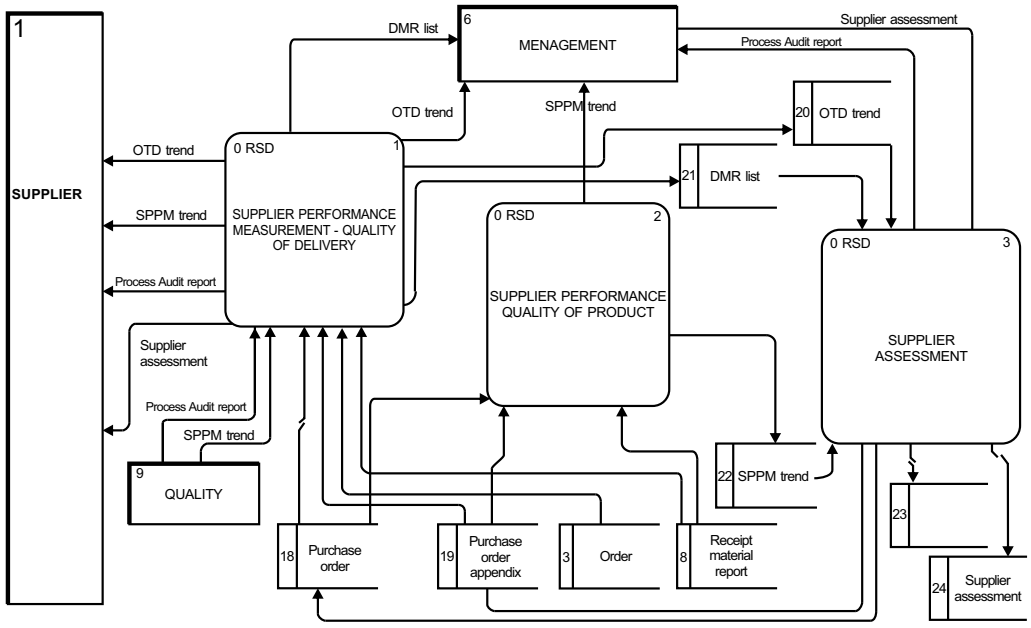

Figure 2 A data flow diagram - Supplier performance measurement

Source: Author

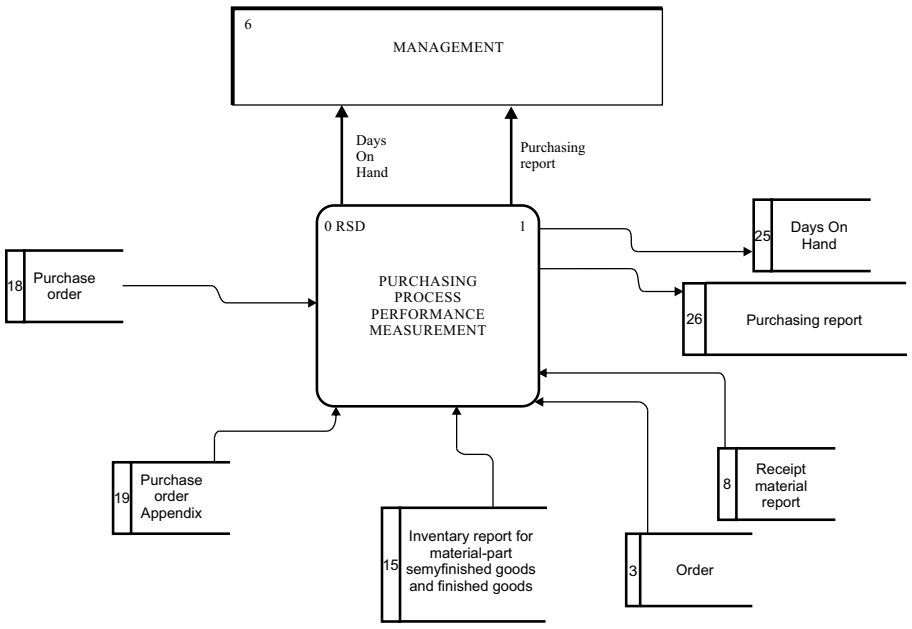

Figure 3 A data flow diagram - The purchasing process performance measurement

Source: Author

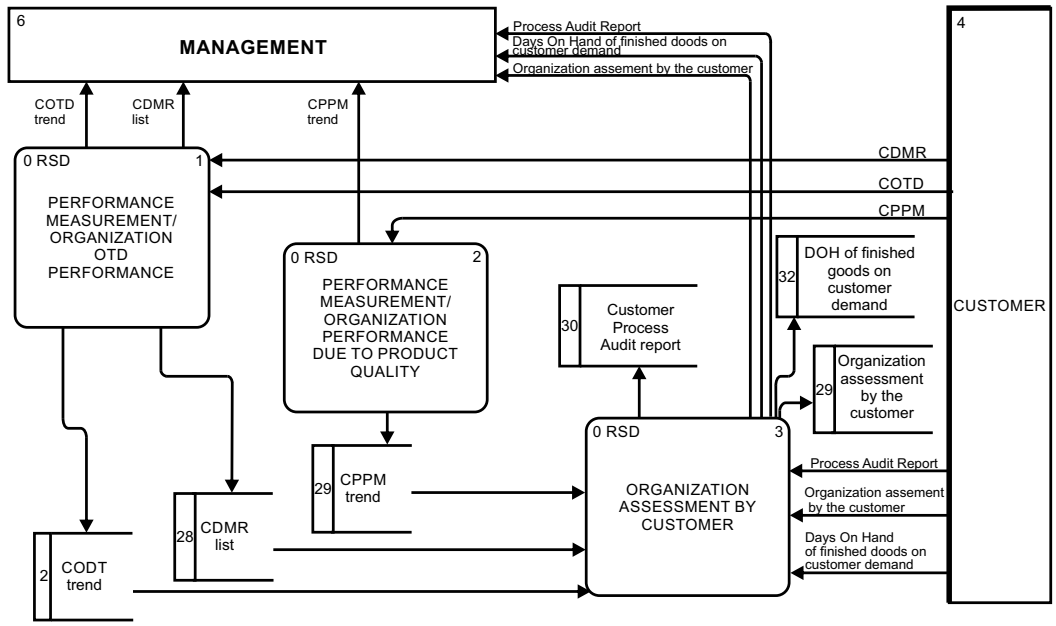

Figure 4 A data flow diagram - The sales process performance measurement

Source: Author

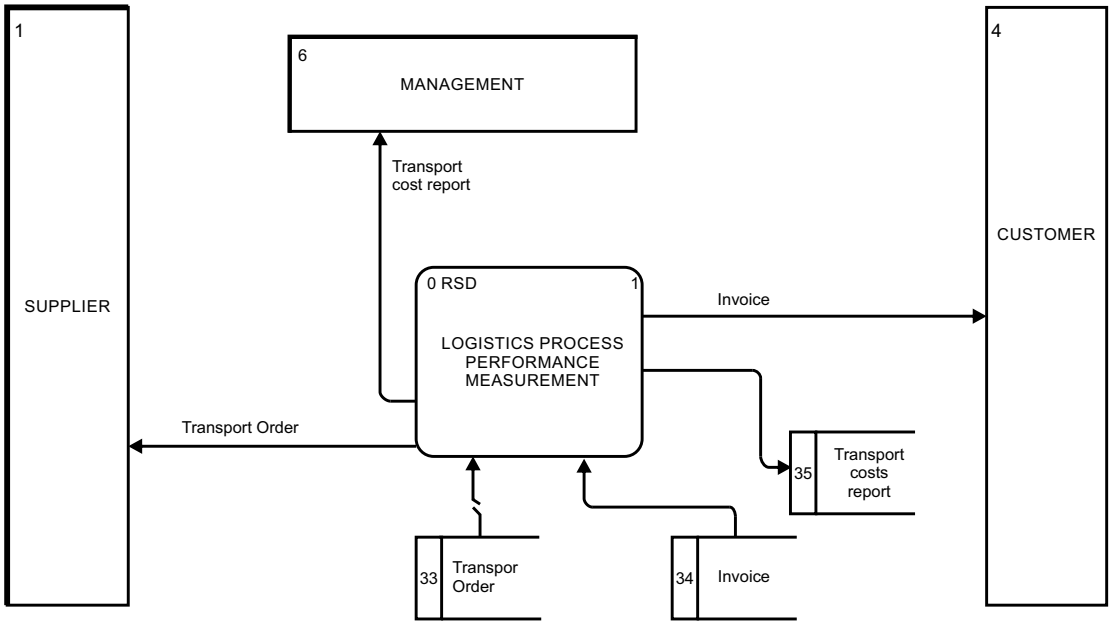

Figure 5 A data flow diagram - The logistics process performance measurement

Source: Author

- the establishing of the relevant characteristics for each entity type, the properties of such characteristics and the determining of the characteristics of the candidates for the primary key.

The basis for the transformation of the process model into the data model is data flows and data warehouses, which are the fundamental characteristics of the system or the state of the system at various time intervals. In this way, each data flow/ data warehouse is transformed into a data model, which consists of the entities hierarchically related to each other.

On the basis of the identified processes and the process storage in the process modeling in e-supply chains and the key performance indicators and the optimization parameters obtained by using AHP methods, attributes are defined as the key properties for data modeling in e-supply chains.

The logical data model for improving business processes in e-supply chains is made by using the ERwin software tool, as shown in Figure 6.

The developed data model forms the basis for designing a database using the appropriate database management software. The end result is a developed application software prototype, as well as a prototype of Web applications to improve business processes in e-supply chains, which allows all members of a supply chain to gain an insight into the movements of the key performance indicators and the overall supply chain performance through the knowledge of the priority and the weights of the KPI for different types of supply chains and through the monitoring of the target and the current values of the key performance indicators of business processes in different types of supply chains.

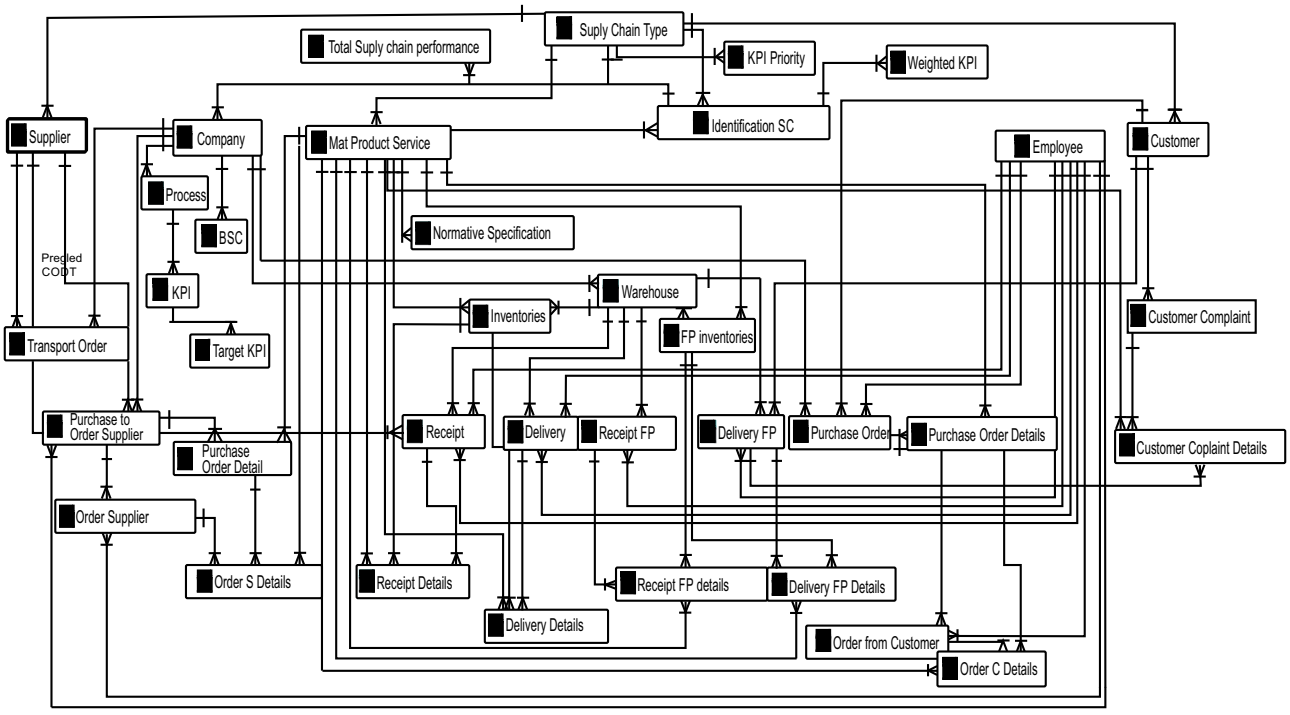

Figure 6 The data model for improving business processes in e-supply chains

Source: Author

RESEARCH RESULTS

The developed Web application prototype was tested with the supply chain member organizations in the automotive industry. After the period of the application software testing, a research study was conducted in order to examine the initial hypotheses.

In the context of this study, the influence of the business process modeling and performance on improving the performance of the key business processes in e-supply chains was tested, with the analysis of the impact of the performance improvement of the key business processes on the efficiency and quality of e-supply chains. Also, research was directed towards the examination of the effect of the improvement of the performance of the business processes on the efficiency and quality of supply-chains, as well as the extent to which the application of the developed management information systems for the purpose of improving business processes in the e-supply chain contributes to the greater efficiency and quality of supply chains themselves.

The empirical research was conducted on a sample of production organizations in the Republic of Serbia in the period September - November 2015. The main instrument of this survey was a questionnaire. When compiling the questionnaire, the starting hypotheses were respected. The questionnaire consisted of 52 questions and was exclusively focused on the management of the organization.

For the purpose of confirming the hypotheses, simple and multiple linear regressions were used. Table 4 accounts for the elements to check the initial hypotheses.

Table 4 The elements for the verification of the hypotheses

	R	R^2	Adjusted R^2	F	sig
The modeling of business processes and performance can define the key business processes in e-supply chains	0.767	0.588	0.583	115.701	0.000
Using Web-based information and communication solutions can improve the performance of business processes in e-supply chains	0.612	0.374	0.366	48.425	0.000
Improving the performance of the key business processes affects the efficiency and quality of e-supply chains	0.935	0.875	0.874	567.496	0.000

Source: Author

Regression analysis, which, among other things, included the determination of the statistics and measures of the representativeness of the regression models and testing the hypotheses on the significance of the regression relationship, established the statistical significance of the effects of implementing the business process and performance modeling and the application of Web-based information and communication solutions on improving the performance of the key business processes in e-supply chains, as well as the statistical significance of the impact of improving the performance of the key business processes on the efficiency and quality of e-supply chains.

CONCLUSION

The developed prototype of the management information system is a system for decision support, which enables the management to identify, structure and solve semi-structured and unstructured problems, and make a choice among different alternatives. By applying the developed information system, the management can quickly and easily obtain information on the key performance indicators for different business processes in different types of supply chains and perform the evaluation and ranking of the supply chains.

In addition, the developed management information system allows the strategic management simulation of a set of the key performance indicators characteristic of the particular type of the supply chain in order to optimize and increase the overall performance of the supply chain. Thus, there is a possibility of simulating different values of each key performance indicator in the set and analyzing its impact on the overall performance of the supply chain. Also, a simulation in parallel with other supply chains is possible in order to achieve the optimal performance of supply chains.

Thus, this system of decision support is aimed at decision making at all levels, but it is of particular importance to higher levels. Through the ability to analyze sensitivity, the system users examine the causality of some alternative routes or examine the consequences that can occur when changing the influencing factors of the selected alternative.

In addition to facilitating the horizontal flow of information, the developed management information system, as a system supportive of decision making, supports vertical information flows, thus helping to integrate the information used at different organizational and management levels of an organization, as well as a number of the organizations that are members of a particular supply chain, enabled by the development of Web-based support to this system.

Interfacing with OEM, customers and suppliers involves an exchange of the displayed indicators and the information accessible via the Web, at users´ request, in a pre-agreed form. The application of this model for measuring the performance of business processes in e-supply chains has led to the improvement of business processes along the entire supply chain, because the developed management information system has generated integrated, faithful and transparent metrics and the performance measurement system. This has facilitated the integration of information from different subsystems for strategic decision making and has achieved the automation of strategic planning and forecasting at the level of supply chains.

Given the distinct interdisciplinarity and multidisciplinarity of the research, in accordance with the defined subject matter and purpose of the research, the hypotheses and the chosen research methods, the theoretical-methodological and practical contribution of this research paper reflects in the improvement of the conceptual models of the processes in e-supply chains, developing models for the improvement of the performance of the business processes in e-supply chains and the development of the management information system model to support the key business processes in e-supply chains.

In developing this management information system model, the subject matter of the conducted analysis was no other business processes in the supply chains, which is the limitation of the research. In the context of the above limitation, future research will focus on the analysis of other business processes in the supply chain, so that future developments will mean their integration into the developed model and the Web application in order to improve the performance of supply chains. Also, the existing model will be extended to other key performance indicators, which will achieve that the overall performance of the supply chain, which in this case was dependent on a large number of the key performance indicators, becomes a measure that will even better portray the efficiency and quality of supply chains, and as such will be used for the evaluation and ranking of different types of supply chains.

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Dragana Rejman Petrovic is an Assistant Professor at the Faculty of Economics, University of Kragujevac, the Republic of Serbia, where she obtained her PhD degree in the scientific field of statistics and informatics. She teaches the academic subject of Information Systems. The key areas of her research work are business and management information systems, business process management, supply chain management and operational management.