The Role of Web-Sphere for Managing Supply Chain Business Objects in Heterogeneous Systems

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***Abstract*— The study discusses the problem of managing supply chain business objects in heterogeneous systems through the use of Business Process Management Systems (BPMS). The purpose of the research is to summarize the experience of domestic enterprises (operating in logistics and other businesses) when using cloud-based logistics systems; to identify general development trends in the domestic market and to develop recommendations for improving the efficiency of supply chain management based on cloud technologies. The research hypothesis is that the competitiveness of the logistics system grows along with its synergy. To test the hypothesis, a survey of 94 respondents working with such systems has been conducted. It has been found that IBM WebSphere is the most preferable system as it provides the maximum synergistic effect that is achieved by the targeted, coordinated, and mutual operation of two or more digital technologies to achieve a certain common goal. In particular, this stems from the fact that it is not enough to produce quality and essential goods or to provide a service; it is important to be able to convey the message to the consumer. The concept of competition has expanded beyond the boundaries of products (goods or services) and has moved into the sphere of competition among management structures. We have developed recommendations to improve the efficiency of supply chain management with the help of cloud technologies based on the monitoring approach.**

***Keywords*—** *Business Process Management Systems (BPMS), supply chain management, IBM WebSphere, synergistic effect.*

1. Introduction

Business as part of the country's economy requires high flexibility. The complexity of production and the demands of consumers are increasing every year: there is a decrease in the volume of product batches and an increase in product range; commodity market has a significant impact on the final price of finished products; service quality is becoming an increasingly important factor in consumer decision making. Production is becoming customer-centric and seeks to be personalized.

Business Process Management Systems (BPMS) model business as a set of business processes. Since the beginning of the Information Age, companies and organizations have been trying to improve business processes with the help of information technologies, and in recent years, there has been a widespread introduction of systems for managing business processes.

There are quite a lot of business process management systems on the software market, and the users of these systems have to choose a system that would ensure the optimal and efficient operation of their organizations. Therefore, an optimality criterion should be determined; in particular, it is important to identify functions that meet the expectations of consumers and their vision of the optimal system.

Supply chain management systems are a combination of digital technologies that interact with each other and with people; these technologies can significantly affect the functioning of such systems, in particular, by reaching synergy. Therefore, a harmonious combination of different models of business processes can be considered as one of the tasks of logistics systems management.

In modern conditions, process management is becoming not only a promising innovation, but also a vital necessity that ensures the functioning of enterprises and optimal use of all resources (material, financial, labor or information resources). In fact, the introduction of a business-oriented management of logistics activities requires integrated vision and penetration into all types of enterprise activities. When modeling and implementing logistics business

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processes, it is necessary to follow a certain sequence of actions; to periodically review and optimize them, as well as to conduct reengineering. In this case, BPMS software that provides the necessary flexibility, functionality, and usability should be used.

2. Literature review

Today, most problems associated with the use of digital technologies in logistics systems (including supply chains) are described in foreign publications and studies of the world's leading companies, organizations, professional groups, etc. In the digital age, logistics is defined as a consumer's ability to independently form a supply chain by choosing communication methods, intermediaries, delivery methods, as well as to track purchases at each stage of their delivery [14].

According to researchers, the operation of logistics systems (including supply chains) in the conditions of Industry 4.0 is characterized by the following trends and features:

- consolidation of Industry 4.0 tools for synergistic supply chain management [1, 2];
- the customer and customer satisfaction are central in the supply chain [3];
- methods and means stimulating demand are constantly increasing; sales channels are developing (primarily due to the development of digital technologies); there are more requirements for the quality of products, as well as for the coherence of all processes from the product order and delivery to the product receipt by the end user [4];
- omni-channel communication is becoming a modern means of communication; it involves a "seamless" online-to-offline transition, that is, the client does not need to take additional efforts to switch from one way of buying and communicating to another [5];
- digital technologies that will be found in logistics systems in the future include: Big Data, Internet of Things, Cloud Computing, Autonomous Robots, Selfdriving Vehicles, 3D-printing, Low-cost Sensor Technology, Augmented Reality, Unmanned Aerial Vehicles, Blockchain, Next-generation Wireless, Bionic Enhancement, Virtual Reality & Digital Twins [12, 13].
- last mile delivery, that is, the delivery from the last logistics center (warehouse, post office, etc.) to the end consumer (household), is of particular importance in the supply chain. One of the main aspects of the development of such delivery is the use of digital technologies, a combination of logistics services, the use of "smart" household appliances, "smart" homes and the like [6].
- environmental friendliness (or environmental responsibility). Transportation load increase generates higher transport demand. Personalization of supplies primarily requires the use of motor vehicles, which is accompanied by significant emissions of harmful substances. Therefore, the focus area of logistics companies is the desire to reduce such emissions, in particular through the use of digital technologies, autonomous electric vehicles, smart containers, and the widespread use of renewable energy sources. In general, green supply chain is becoming the main concept of modern logistics and supply chain management [7].
- supply chain operation is impossible without the occurrence of reverse flows. In reverse logistics (Back Supply Chain Management (BSCM)), the object of logistics management is the reverse logistics flow. Reverse logistics is based on the following processes: returning, disposal and recall, remanufacturing, repair and service, recycling, salvaging [8]. In view of this, the concept of a supply chain is being expanded; the categories of Extended Supply Chain, Closed-Loop Supply Chain and Circular Supply Chain appear. They reflect the unity and interpenetration of traditional and reverse logistics, direct and reverse logistics flows [9].
- despite the widespread use of digital technologies (primarily robotics) in logistics, intellectual technologies are still the most important resource. The competitive advantage of a supply chain is that management decision-making is more reasonable due to the use of digital technologies. It is predicted that the role of a person will shift from an active participant into a controller and observer of supply chain processes. It is also expected that there will be intelligent systems able to fully replace a person and increase the efficiency of performing routine, repeated, and physically complex logistic operations [10].

All these features of the modern supply chains are interdependent. According to the researchers, digital technologies will play a major role in the era of Industry 4.0. Their combination will have a synergistic effect on the supply chain. Mutual effect is achieved through the interaction of various factors in the supply chain ensuring focused, coordinated, and mutual operation of two or more digital technologies to accomplish a certain common goal [11].

The development of supply chains within Industry 4.0 will contribute to the emergence of completely independent of human production and, accordingly, logistics networks. In this case, 7PL operators are expected to appear. Further scientific and technological progress will stimulate the emergence of higher-level operators (8PL, 9PL, ...) [15].

Supply chain management most clearly reflects the shift from Human to Human (H2H) interaction model to Machine to Human (M2H), Human to Machine

(H2M) or Machine to Machine (M2M) models [16]. In general, innovations in supply chain management are systemic and unique; they are manifested through a synergistic effect, and are the result of a highly effective management process.

2.2 Setting objectives

Agricultural There are quite a lot of business process management systems on the software market, and the users of these systems have to choose a system that would ensure the optimal and efficient operation of their organizations. At the same time, despite the variety of different studies and the accumulated world experience in using various systems for supply chain management, there is a lack of research summarizing the trends and developments of the domestic supply chain management based on various cloud systems.

It can be hypothesized that the competitiveness of the logistics system grows along with its synergy.

The purpose of the research is to summarize the experience of domestic enterprises (operating in logistics and other businesses) when using cloud-based logistics systems; to identify general development trends in the domestic market and to develop recommendations for improving the efficiency of supply chain management based on cloud technologies.

The research objectives include:

- theoretical consideration of the main capabilities of business process management systems and the analysis of the operation of existing systems;
- identification of the most functional and the most competitive systems;
- development of recommendations for improving the efficiency of supply chain management through the use of cloud technologies.

3. Methods and materials

3.1 Research context

A heterogeneous network business management system is a combination of heterogeneous computer programs that implement a series of individual business, information and service models. Today, it is necessary not only to use the functional scope of the enterprise, but also to provide for the possibility of reengineering individual business processes that correspond to the general business concept of the enterprise in order to manage complex systems of supply chains.

Enterprise process management can be effectively supported by the implementation of information systems, for example, Business Process Management Systems (BPMS), namely, ELMA, EMC Business Process Manager, IBM WebSphere Business Integration Modeler, ARIS Business Architect, Intalio, JBoss jBPM, Lombardi Teamworks, Microsoft BizTalk Server, Oracle BPM Suite, SAP NetWeaver, Ultimus BPM Suite, Unify NXJ. These systems significantly improve the interaction between individual supply chain processes by comprehensively implementing functions from simple requests to modeling complex business processes with cross-platform weak connections between different users and service providers.

3.2 Research hypothesis

An integrated supply chain management system is primarily designed for small and medium-sized companies that do not usually require highly qualified economists, analysts, IT specialists, and programmers; an integrated system allows the implementation and testing of a complete set of business functions in the field of supply chain management through the use of one integrated software package rather than integrating a number of complex information technologies.

3.3 Research methods

We conducted a survey in order to summarize the subjective practice of using BPMS to manage supply chains. To conduct a monitoring study, a multi-stage sampling entailing two stages was used. The first stage involved the total population of the country. The number of respondents from each region was selected in proportion to the total number of residents living in the region. The selection was performed in a random systematic manner. Recruitment was conducted based on the Computer-Assisted Telephone Interviewing (CATI) method. Randomly dialed respondents were invited to participate in an online survey. At this stage, 3.121 respondents were randomly selected; 96 of them noted the use of BPMS to manage supply chains and were ready to take part in the survey.

At the second stage, the respondents were asked to switch to an online survey. There were 94 people who agreed to participate in the survey that contained the following questions:

- What programs do you use? Are you considering switching to other programs?
- What program parameters do you find the most important? - To what extent does the program you use meet the requirements?

To conduct the survey, we used an online panel. This means that the respondents were a group of registered Internet users who realized that they had agreed to participate in marketing research on a paid-for basis.

We believe that the approach is feasible and provides reliable results.
Data quality control involved the following procedures:
- survey data were compared with profiling data and the data obtained in other projects; participation was restricted by a certain time frame;
- multiple registrations were checked with the help of built-in functions;
- uniqueness was controlled.
The sampling error did not exceed 5%.
Questionnaire questions are our own development.

4. Results

The survey results were generalized and tabulated, and the percentage values of the responses were given.
The following programs proved to be the most common: IBM WebSphere, Oracle BPA Suite, Lombardi Teamworks - they are used by 91 respondents (96.8%). At the same time, 30 respondents (31.9%) stated their willingness to switch to another program; they were mainly users of Oracle BPA Suite and Lombardi Teamwork's.
According to the respondents, the most significant characteristics of the systems are quality and traceability, as well as fast and optimal planning. Quality and traceability involved compliance with regulatory requirements, determination of maintenance costs to improve the product, customer security, monitoring of every supply chain stage, and supply route tracking. Improved planning is a key parameter for companies that are characterized by expensive inventories, labor-intensive production, rapid customer changes, and variable demand. Fast forecasting of order fulfillment and asset efficiency were noted as less significant. Automated forecasting provides a quick response to orders. Asset efficiency is a focus on maximizing the efficient and economic use of assets in production. Table 2 demonstrates the degree of conformity of the programs used by the respondents with the stated requirements.
Thus, according to the respondents, IBM WebSphere is the most optimal. The respondents believe that the system provides a synergistic effect in supply chain management, which involves:
1) cost minimization at each supply chain management stage (the use of the system component resources allows saving resources; reducing the cost of collecting, processing and transmitting information; reducing the cost of controlling the quality of logistics operations; sharing costs between components of the logistics system, etc.);
2) improved operation of the logistics system (by improving the quality of customer service (in particular after-sales service), increasing sales; reducing the time of movement of material flows in the logistics system; flexible product pricing and product delivery without minimizing the total profit in the logistics system, etc.);
3) increased competitive advantages within the logistics system (coordinated interaction of the logistics system components (enterprises in the supply chain) increases the competitive advantages and market share of goods and services due to the narrow specialization and the provision of integrated services).
Thus, the survey data make it possible to empirically confirm the hypothesis that the competitiveness of the logistics system grows along with its synergy. We believe that it is not enough to produce quality and essential goods or to provide a service; it is important to be able to deliver it to the consumer. The concept of competition has expanded beyond the boundaries of products (goods or services) and has moved into the sphere of competition among management structures.
In addition, the parameters that are important from the respondents' point of view characterize various aspects of monitoring rather than the control of the supply chain. Thus, monitoring of every supply chain stage is defined as the most important BPM factor

Table 1. Determination of important program parameters

Program/Number of respondents	Degree of importance (0-5)	IBM WebSphere	Oracle BPA Suite	Lombardi Teamworks	Other
Number of program users	-	48	25	18	3
Willing to switch to another program	-	0	11	10	2
quality control and traceability (quick review of the history of operations)	5 (4 for the programs to manage expensive inventories, labor-intensive production, rapid customer changes, and variable demand)	28	15	10	1
fast and optimal planning	4 (5 for the programs to manage expensive inventories, labor-intensive production, rapid customer changes, and variable demand)	11	4	4	1
fast forecasting of order fulfillment (quick determination of delivery time)	3	5	3	2	1
asset efficiency (focus on maximizing the efficient and economic use of assets in production)	3	3	1	1	
Reduced cycle time (time between order placement and production)		1	1	1	
flexible production (quick change of production settings to form new supply chains)		2	1	1	

Table 2. Program conformity with the respondents' requirements.

Indicator/Number of respondents	Fully	For the most part	Partially	Would like to switch to...
quality control and traceability				
IBM WebSphere	29	14	5	-
Oracle BPA Suite	9	11	5	IBM WebSphere
Lombardi Teamworks	2	8	8	IBM WebSphere
fast and optimal planning				
IBM WebSphere	25	18	5	
Oracle BPA Suite	14	7	4	IBM WebSphere
Lombardi Teamworks	11	5	2	-
Fast forecasting of order fulfillment				
IBM WebSphere	22	20	6	-
Oracle BPA Suite	11	12	2	IBM WebSphere
Lombardi Teamworks	11	5	2	IBM WebSphere
Reduced cycle time				
IBM WebSphere	27	15	1	-
Oracle BPA Suite	9	15	1	-
Lombardi Teamworks	5	4	9	IBM WebSphere
flexible production				
IBM WebSphere	32	14	2	-
Oracle BPA Suite	14	11	0	IBM WebSphere
Lombardi Teamworks	8	9	1	-

5. Discussion

The studies and accumulated experience [17, 18, 19] indicate that a single introduction of an optimized or completely changed business logistics will not increase business efficiency. This can be achieved only through the periodic review and change of the process.

We believe that the parameters singled out by the respondents as the most important are determined by the environmental instability. On the other hand, such instability is an incentive for the development and implementation of innovations. Business process reengineering is a competitive advantage of supply chain management systems. In general, the synergistic effect is also achieved due to the visualization of processes, the availability of forecasting tools, the identification of "bottlenecks", a quick response to external changes (for example, consumer demand) and the improvement of decision-making.

A model for monitoring business processes can be developed based on the set of indicators; there are different scenarios for the process implementation. Simulation tools should be used for monitoring the process in each scenario in order to regulate the sequence of events and influence the results of the process, make various decisions on the process structure.

In management, especially in the management of an integrated supply chain, the monitoring system plays an extremely important role. Competitiveness is dramatically affected by the monitoring system upon the given quality of goods and customer service, smooth production, marketing, and supply.

Modern BPMS allow working with big data of information, financial, and material flows, which also include data on personnel, equipment and technologies, competitors and external factors. This information is used for planning, forecasting, reengineering, and analysis of the whole system.

Monitoring will ensure the management of timely and high-quality information; it will compare the available performance indicators with the expected result (Figure 1).

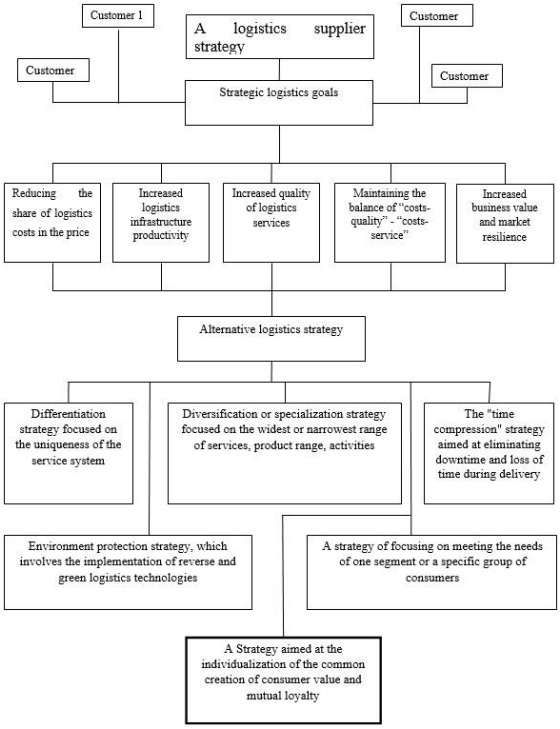

Figure 1. Logistics strategy development based on the synergy of all components and the monitoring approach

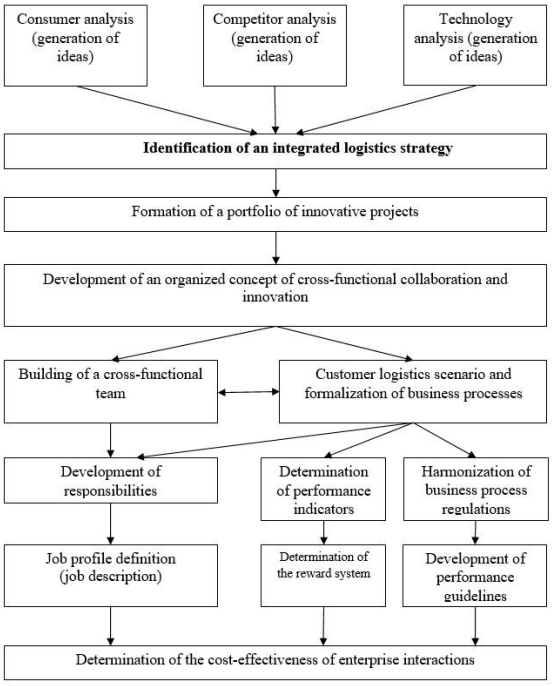

Figure 2. Identification of an integrated logistics strategy

The development of a general logistic strategy involves process monitoring, which allows preventive elimination of potential "bottlenecks" and possible risks, supply chain optimization, as well as minimization of the consequences of situations that require intervention.

Monitoring of information, material, and financial

flows is the basis of the process synergy in logistics systems, as it contributes to rational planning and provides competitive advantages.

In this case, the following components can be distinguished in the monitoring mechanism:

- supply chain optimization criterion;
- functions and tools used to achieve optimization;
- maintaining of management processes.

The general logistic strategy can be implemented provided that BPVS is based on a systematic approach, comprehensiveness, sustainable development, timeliness, and documentation.

The monitoring system can be formed only in the context of the overall management strategy of the logistics system, which includes:

- development of a general logistics strategy based on the selected optimization criterion (reduction of costs in the supply chain, total profit increase, maximization of territory coverage, increase in the number of customers, etc.)
- development of criteria for the selection of intermediaries; their selection based on the optimization criterion;
- monitoring of all supply chain stages;
- contract execution monitoring;
- completion of contracts based on contract execution monitoring;
- optimization criterion correction.

6. Conclusions

Business process management systems allow the implementation of all supply chain management principles: the principles of consistency, comprehensiveness, sustainable development, timeliness, and documentation.

The survey on the most important parameters of Business Process Management Systems revealed that the most competitive programs are the ones that provide a synergistic effect of all supply chain components and allow monitoring aimed at risk prevention rather than mitigating its consequences.

Most users prefer IBM WebSphere as it maximizes synergy through the interaction of several digital business process management technologies.

The respondents also noted the importance of the following parameters that should be implemented with the help of Business Process Management Systems: quality control and traceability (quick review of the history of operations); fast forecasting of order fulfillment (quick determination of delivery time); fast and optimal planning; asset efficiency (focus on maximizing the efficient and economic use of assets in production); reduced cycle time (time between order placement and product manufacturing); flexible production (quick change of production settings to form new supply chains).

According to the users, the main advantage of IBM WebSphere is the ability to monitor every supply chain stage, namely, the ability to quickly determine the history of operations and ensure rational planning. The synergistic effect of IBM WebSphere is realized through:

1) cost minimization at each supply chain management stage;
2) improved operation of the logistics system;
3) increased competitive advantages within the logistics system.

Technologies for implementing competitive advantages make it possible to control various flows in supply chain management.

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