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Methodology of effective application of Big Data and Data Mining technologies as an important anti-crisis component of the complex policy of logistic business optimization

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Abstract. *The purpose of the research* is divided into two, sequential and related phases: a) development and configuration of a comprehensive policy of optimization of the logistic business as an integral part of the anti-crisis measures, taking into account the domestic national specifics, sector specifics of the transport industry in the current systemic political and macroeconomic crisis; b) considering the importance of optimizing the information management of the logistic company (as an important component within the framework of the developed anti-crisis optimization policy). The next goal of the article is to develop a methodology for hybrid effective use of innovative technologies of Big Data and Data Mining within the framework of adaptive logistic information system for logistic companies. *Methodology.* Special attention is paid to optimization of information management of a logistic company (8th and 9th stages within the framework of the above-mentioned policy of optimization of logistic business) with the use of innovative technologies Big Data and Data Mining. *Results.* Taking into account the negative influence of the global, national and sectoral factors of management, the authors, taking into account the current political and macroeconomic crisis, offered a comprehensive policy of optimizing logistic business (consisting of 9 detailed stages) as an integral part of the anti-crisis policy of the logistic company. Taking into account the specialty chosen by the authors (Mathematical methods, models and information technologies in the economy), within the framework of which scientific research is carried out, special attention is paid to optimization of information management of a logistic company (8th and

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9th stages within the framework of the above-mentioned policy of optimization of logistic business) with the use of innovative technologies Big Data and Data Mining. *Practical meaning.* The obtained results are relevant and applicable not only for local logistic companies, but also for international applications in the context of projected global macroeconomic and current national crisis phenomena. *Prospects for further research.* The prospect of further practical use of the obtained results confirms that the above results have already been used by the authors in designing an adaptive logistic information system for domestic companies, and the manuscript of authors' design decisions has already been submitted for publication and review.

Keywords: anti-crisis policy, logistic company, optimization, data mining, big data.

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Методологія ефективного застосування технологій Big Data та Data Mining як важлива антикризова складова комплексної політики оптимізації логістичного бізнесу

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Анотація. *Мета дослідження.* Мета даної статті ділиться на два, послідовних і суміжних етапи: а) розробка та налаштування комплексної політики оптимізації логістичного бізнесу як невід'ємної частини антикризових заходів з урахуванням вітчизняної національної специфіки транспортної галузі в умовах сучасної системної політичної та макроекономічної кризи; б) розгляд важливості оптимізації управління інформацією логістичної компанії (як важливого компонента в рамках розробленої антикризової політики оптимізації). *Методологія.* Особлива увага приділяється оптимізації інформаційного менеджменту логістичної компанії (8-й і 9-й етапи в рамках вищезгаданої політики оптимізації логістичного бізнесу) з використанням інноваційних технологій Big Data і Data Mining. *Результати.* В статті, з урахуванням національної специфіки, галузевої специфіки транспортної галузі та з урахуванням поточної політико-макроекономічної кризи, викладені результати досліджень щодо розробки та конфігурування комплексної політики оптимізації логістичного бізнесу, як невід'ємної складової антикризових заходів. Враховуючи обрану авторами спеціальність (Математичні методи, моделі та інформаційні технології в економіці), в рамках якої здійснюється наукове дослідження, особлива увага приділяється оптимізації інформаційного менеджменту логістичної компанії (VIII та IX етапи в рамках вищезгаданої політики оптимізації логістичного бізнесу) з

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використанням інноваційних технологій Big Data і Data Mining. Зокрема, досліджено практичний досвід функціональних завдань та алгоритмічне забезпечення використання технологій Big Data та Data Mining міжнародними логістичними компаніями, визначено проблемні питання та надані відповідні рекомендації для вітчизняних логістичних компаній. Розроблена методологія сценарно-гібридного ефективного використання технологій Big Data та Data Mining в рамках адаптивної логістичної інформаційної системи. *Практичне значення*. Отримані результати є актуальними та прикладними не тільки для локальних логістичних компаній, але і для міжнародного застосування в умовах прогнозованих глобальних макроекономічних та поточних національних кризових явищ. *Перспективи подальших досліджень*. Перспектива подальших розробок підтверджує, що одержані результати будуть використаны авторами при розробці адаптивної логістичної інформаційної системи для вітчизняних компаній, а рукопис проектно-конструкторських рішень вже подано для розгляду та публікації.

Ключові слова: антикризова політика, логістична компанія, оптимізація, data mining, big data.

1. Introduction.

World logistics is one of the largest industries in the world, which includes transportation by land, air and sea transport. The share of the transport market in world GDP is about 10%, which in the monetary equivalent is about 4 trillion dollars (Myrovaia lohystyka: poniatye, tendentsyy, statystyka). The logistics industry is one of the fastest growing. Experts say that in the near future, the growth of this type of business will be influenced by the markets of China and India. The analysis of the logistic market has helped to determine that road freight is the most popular logistic developed in European countries.

No less in demand is also air transportation. More than 70% of all traffic between Asia and Europe is carried by airplanes. Almost 90% of deliveries of goods are made by air transport. An active growth of the global fleet is expected by 2030, it will amount to almost 3,000 units. A slightly smaller share in the global logistic business is maritime traffic. But in terms of cargo tonnage, they surpass air and road freight. By sea transport are usually transported cargoes and goods that have a long period of term of realization. But global economic crises are instantaneous, regular and unfavorable across the entire industry (*Krasnyuk and Kustarovskiy, 2017c*).

The analysis of the current international practice of the subject area shows the following global factors that have a significant and permanent impact on the information management of modern logistics 3PL (*Fauziah Abdul Rahman et al., 2014*):

- Excessive space of decisions and their multidisciplinarity (when making managerial decisions in the field of international logistics, the number of varied input variables, their combinations, and the corresponding variants of complex and unbalanced scenarios grows);

- the emergence and improvement of innovative IT-technologies (which, in particular, provide total opportunities for registration, transmission, storage, processing and automated analysis of all logistic data, events and conditions);

- comprehensive globalization, on-line competition and the complexity of the market structure of international multimodal logistic services lead to new and increasing influence of known factors of uncertainty and incompleteness of logistic data, increase of “informational noise”;

- the growth of the dynamics of the fluctuations of subjective and objective factors, the increase in the proportion of anomalies in the data, the change in the laws of their interaction, the change in the significance of factors in the already built models (in which there is an urgent need not only to automatically respond to these dynamics in real time, but and to automate verification and re-training of existing models);

- a radical increase in flows of logistic

unstructured data of all types from stand-alone devices, sensors.

In the development strategy of Ukraine, the transport industry also plays a leading role, since an efficiently functioning transport communications system is the basis without which renewed sustainable economic growth of the country is impossible. However, the current state of the industry in Ukraine can clearly be characterized as a systemic crisis, as since 2009 the economy began to reduce production volumes and sales, later in 2011-2012 began the period of stagnation began (*Hrashchenko and Krasniuk, 2015*). However, already at the end of 2013 – beginning of 2014 – under the action Including external factors, the systemic political and paramilitary-economic crisis has developed, which further worsened the state of the domestic transport industry.

That is why, after dramatic devaluation of hryvnia and the actual stop of the important transport corridors (the North of Ukraine – Crimea, the West and the Center-Donbass), many carriers were forced to leave the market because they could not maintain their leasing and lost all liquidity (due to the crisis of non-payments of standard receivables under annual contracts for 2013-2014 and multiple increases in rates for short-term operating overdraft in 2014).

Despite the above obstacles, which have significant and permanent influence on the management activities in the field of international logistics, the conducted analysis and diagnostics of the domestic logistic industry for 2012-2013 (we emphasize – the period to the acute phase of the current crisis) has been shown (*Krasnyuk, Herashchenko and Kustarovskiy, 2018*), that the systemic problem for the logistic management of the domestic network company was still the lack of a coherent formalized model of management of logistic business processes and, as a result, subjectivism and intuitive (manual) management. As the actualized analysis of 2017 shows, despite the 4th year after a major crisis, this practice is proceeding. Taking into account the above, it is possible to elaborate additional urgent problems of the crisis management of Ukrainian logistic companies:

- absence of formalized logistic business processes and corresponding corporate standards (or lack of automation of control over their implementation);

– "manual" and occasional management of the quality of logistic services and loyalty of customers;

- significant influence on the indicators of the logistic company's incompetence / subjectivity / abuses from the side of operational management;

- the lack of automation and objectivity in predicting demand for logistic services, and, consequently, the decline in operational efficiency;

- occasional and partial use of all accumulated and / or available internal and external data (especially real-time streaming data); weak or no impact of the results of the analysis of the above data not only on the operational level, but also at tactical and strategic management level.

Taking into account the foregoing, the unconditional relevance for domestic forwarding companies is the task of developing and configuring a comprehensive policy of optimizing the logistic business (taking into account national, sectoral and crisis specifics) as an integral part of the anti-crisis measures.

Also, given the importance of optimizing the information management of the logistic company, within this policy of optimization, the important innovative tools are technologies Big Data and Data Mining, this is why the problem of the formation of a detailed methodology of their hybrid and efficient use is relevant (taking into account national, sectoral and crisis specifics) within the framework of adaptive logistic information system.

2. Literature review.

Although theoretical studies of crisis management are sufficiently substantiated in the works of O. S. Voroninoyi, K. I. Voennoyi, T. V. Gavrilenko, N. O. Kovalchuk, L. S. Kravchuk, A. O. Pavluk, Ye. A. Pryadunа, V. I. Fuchegy, however, they did not pay

attention to the comprehensive optimization of the logistic business (and the choice and configuration of the relevant tools and algorithms) as an important anti-crisis measure.

Some aspects of Data Mining or Big Data are partly disclosed in the works of Angela S. H. Lee, A. Borisov, B. Annegret, P. Chandrasekar, D.-H. Lee, F. A. Rahman, J. Tolujevs, I. Nordin, K. Nassar, M. Jeske, M. I. Desa, M. Grüner, N. A. Haris, P. Abraham, V. Saravanan, P. Thangaiah, S. Hasan, S.-T. Jeng, S. M. Shamsuddin, S. K. Barai, W. Frank, however, in the analyzed works not only were not taken into account the domestic specifics of the logistic market, the question of the formation of a holistic methodology for the effective use of such technologies, but also absolutely was not focused on the hybrid application of these technologies as an important tool within the anti-crisis policy optimization for a logistic company.

3. Methods.

Special attention is paid to optimization of information management of a logistic company (8th and 9th stages within the framework of the above-mentioned policy of optimization of logistic business) with the use of innovative technologies Big Data and Data Mining.

4. Research objectives.

Thus, taking into account the above, the purpose of this article is divided into two, sequential and related stages:

a) development and configuration of a comprehensive policy of optimization of the logistic business as an integral part of the anti-crisis measures, taking into account the domestic national specifics, sector specifics of the transport industry in the current systemic political and macroeconomic crisis;

b) in addition, taking into account the importance of optimizing the information management of the logistic company (as an integral part of the anti-crisis policy optimization developed in the first step), the second goal of the article is to develop a methodology for hybrid efficient use of innovative technologies of Big Data and Data Mining within the framework of adaptive logistic information system.

5. Results and discussions.

Taking into account the above-mentioned results of the analysis of the crisis situation of the domestic logistics business, an important and priority task within the framework of anti-crisis measures is an increase in the profitability of domestic logistic companies. Consequently, in logistics, as in other industries, there are three main ways to increase the profitability of a business:

1) the first – the growth of tariffs for services. The industry's specificity is that there are many small private carriers operating on the market who agree on a low price, and buyers count every penny in a crisis.

2) the second way is to reduce costs. Of course, such a reduction can reasonably be carried out only after a comprehensive audit, the methodology of which is set out in (*Krasnyuk and Kustarovskiy, 2017a*). However, in a highly competitive market, direct reduction of expenses without reorganization of business processes can lead to a drop in the quality of logistic services and an increase in all types of risks of a logistic activity.

Taking into account the foregoing, in the framework of the anti-crisis strategy, considering sectoral and domestic specificities, particular attention should be paid to the quality management policy (TQM) and, accordingly, the analysis of the relevant costs. In particular, TQM costs are divided into three types (*Abraham, Saravana and Thangaiah, 2011*): costs of loss of cargo, fines for delay, etc.; expenditure on the implementation of assessment and quality control; warning and insurance costs. Moreover, the high quality of the service is not proportional to the high costs, because effective TQM policy and timely allocated funds for covering the costs of the 2nd and 3rd type necessarily greatly reduce the first type of the expenditure (which, if it happens, can even lead to the bankruptcy of the logistic company).

3) the third way to increase profitability

is to systematically optimize business. Moreover, this method of crisis management should aim at systematic and coordinated (as all these areas at all levels are interrelated and do mutual synergistic effect) optimization of all functional components at all dedicated levels of management of logistic or forwarding company. For example, approximately 90% of all products turnaround time of goods production in different stages of logistic processes, even separate functional optimization can reduce logistic operating costs by at least 10-40%.

Let's outline the results of research on component composition and task tools for optimizing logistic business:

1) optimization and automation of inventory control policy (the formation and maintenance of such magnitude stocks in the context of different compositions, which will ensure an uninterrupted supply range at minimum costs).

Along the logistic supply chain, stocks take the form of: raw materials, semi-finished products, work in progress, and finished products. Reducing even a few paragraphs of logistic costs stocks at the beginning of the logistic network – in the end times can increase profitability at the end supply chain (*He, 2013*). In addition, the optimal level of stocks should prevent the shortage of raw materials, maintain the continuity of the production process and quickly meet the needs of customers. Thus, achieving the optimal level of stocks is an important task of managing logistic chains, especially in the above-described domestic industry conditions.

The task of optimizing stocks, in turn, is divided into three subtasks:

- optimization of volumes (calculation of optimal insurance stock taking into account forecasts of fluctuations in demand, specified delivery terms, transport, warehouse and other restrictions, which reduces the costs of storage and transportation);

- optimization of the assortment (formation of the optimal product range by means of a reasonable choice of terms of suppliers and goods procured in terms of product groups, taking into account the cost of storage and delivery to the warehouse, the declared terms of storage of goods, the availability of substitute goods, warehouse characteristics, which in general reduces the excessive amount of illiquid goods). To solve the problem of optimal assortment, the authors propose the use of such an algorithm of Data Mining as the search for associative rules, through which you can not only identify potential additional needs of customers and offer new products and services based on them (to optimize the range), but also to optimize the placement of goods for account of the analysis of together purchased goods, thereby minimizing internal storage.

- optimization of places of placing of stocks (warehouses) (taking into account possible penalties for late delivery or not delivery to the customer).

In addition, after formalizing and deploying in the logistic information system the objective and verified patterns obtained during the DM, it becomes possible to implement automation of the formation of auto-order and procurement calendar, which automates and / or verifies the routine actions of the forecasting and planning manager, which in turn – reduce the likelihood of errors and corruption risks.

2) optimization of routes and schedules (optimization of time, length and cost of routes, analysis and optimization of multimodal supply chains, optimization of orders for single- or two-stage cross-docking, etc.). It should be noted that in order to increase the efficiency of optimizing complex routes (for example, multi-modal with through-warehousing), it is necessary to distinguish between the following possible constraints:

- routing if many stops are required;

- routing, provided that there is a time window;

- routing taking into account weight restrictions;

- routing considering established limits on delivery terms.

The decomposition of the above restrictions should be taken into account when

choosing a method for solving transport problems.

3) optimization of finance.

It should be noted separately that prior to the development of measures to optimize the finances of the logistic company, it is imperative to conduct a financial analysis according to the method proposed by the authors (*Krasnyuk and Kustarovskiy, 2017a*).

Optimization of the financial sector of the logistic company (taking into account the results of the preliminary financial analysis and audit) should begin with the construction of a model, which minimizes operating and overhead costs for: transportation, storage and penalties. However, this model should take into account the impact of the following attributes and restrictions:

- full or insufficient loading of transport;
- shortage of demand;
- net demand
- the range is actually available
- stock shortages
- supply volumes
- the cost of penalties for delay in shipment, early shipment and use of emergency stocks
- transit supply
- number of flights
- violation of storage limits by volumes and duration of storage
- number of deliveries of the product
- the number of vehicles
- the cost of transferring stocks between warehouses.

This is not an exclusive list of attributes for the financial model, because for each logistic company after the audit and statistical analysis, OLAP and DM, other attributes that take into account the specifics of the company, regional and national specificity should be added.

In particular, it is proposed to solve this complex of problems, to use in a competitive mode the tools of logistic regression and evolutionary modeling (for example, the algorithm FL).

4) optimization of fixed assets – the loading and rational use of available and borrowed out of the outsourcing resources;

5) optimization of personnel – rational use of personnel, compliance of the functions performed by the level of training and qualification of employees;

6) optimization and improvement of the quality of business processes (will be considered by the authors in the following publications);

7) optimization of risks (Risks of logistic systems and their modeling considered by the authors in (*Krasnyuk, Herashchenko and Kustarovskiy, 2018*) depend on many internal and external factors: from the price situation and changes in demand and ending with the activities of competitive organizations and natural disasters. The authors, for solving this problem, propose the scenario use in the mode of DM toolkit decision trees and neural networks);

8) optimization of information resources – fidelity, accuracy, efficiency, timeliness, performance and interpretation of the results of processing and analysis of data. To solve this stage of optimization, the authors below outline the results of the developed comprehensive methodology for the effective use of Data Mining technology for domestic logistic companies.

9) optimization and obtaining additional value added from accumulated corporate data, intangible assets and knowledge (*Krasnyuk, 2006*). Below are the results of the comprehensive methodology developed by the authors for the effective use of the Big Data technology for domestic logistics companies.

It should be noted that authors suggest to carry out the 8th and 9th stages in a coordinated manner, due to the characteristics and peculiarities of using Big Data and Data Mining technologies (discussed below).

The 9th component task of the optimization of the logistic business is complex, long enough, requires significant expert resources. Therefore, the authors propose a step-by-step project implementation of the above task in the order that corresponds to the numbering (except for the 8th and 9th stages).

It is clear that all of the above nine areas of optimization integrated affect the profitability and robustness of a particular logistic business. Given the foregoing, it is clear that the business profitability model needs to be periodically verified and adapted not only through radical changes in macroeconomic conditions, for example, after complex crisis phenomena 2013-2014, but also through the results of the above-mentioned optimization steps.

Further, taking into account the aims of the article, attention will be paid to the results of the 8th and 9th steps of the comprehensive integrated logistis domestic business policy outlined above.

Consequently, based on the experience gained, it can be argued that the use of traditional information technologies for the transport industry (OLAP, statistical analysis) for conducting a cardinal and comprehensive optimization of the multi-factor model of profitability is not enough in terms of crisis management, especially given the domestic specificity. In particular, the results of corporate research and testing show that the prediction error in the tasks of forecasting the demand of users through traditional statistical approaches can reach 60% (*Sinn, 2012*).

That is why the authors suggest hybrid use of Big Data and Data Mining technologies as part of the design of an adaptive logistic information system for domestic business (the results of designing the logistic information system will be published in the following publications of the authors).

Further, in the text, the results of studies on the effective use of Big Data technology as a key factor for the effective implementation of the 8th and 9th steps of the above comprehensive policy of optimizing logistic domestic business will be outlined.

This factor is especially important for logistic companies that have already introduced automated logging systems for logistic chains (*Krasnyuk and Kustarovskiy, 2017b*): modern technologies for automatic identification and registration, hardware and software complexes for managing and coordinating warehouse equipment, control means for the movement of vehicles and tracking postal items, flow data from various sensors of humidity, pressure, temperature, speed, etc. (*Brandau and Tolujevs, 2013*). Such systems register in 24/7/365 mode and store huge volumes of heterogeneous information (quantitative, qualitative, textual, multimedia, etc.) for events in various aspects of logistic activity (for example, logistic processes in the electronic commerce of BtC) (*SupplayChain247, 2013*). Moreover, the speed and detail of such flows are increasing. In particular, surveys of European companies have shown that almost half of them expect annual growth of their data flows by 25% (*Bange, Grosser and Janoschek, 2013*).

Especially during the crisis, many unpredictable violations in chains of supply occur, for example, traffic congestion, accidents, human errors, natural disasters, fraud and corruption. For this reason, 3PL companies should monitor their processes in real time so that not only post-factum reaction to the critical situation was as fast as possible, but also to anticipate the occurrence of such events and to take precautionary measures in advance.

Again, to hope that the results of the application of classical methods and technologies for processing these accumulated data (all the more so if in logistics is relevant the need to analyze not just a set of factors, but also their possible different combinations, taking into account the possible impact of the subjective human factor) will radically change the current trends of the company (especially in such a highly competitive and low-profitable industry as logistics) is useless. This is confirmed by the results of the study of current and planned investments in logistics, more than 60% of 3PL respondents plan to invest in sphere of Big Data in the next 5 years (*Handfield et al.,*

2013).

The conducted studies have shown that the introduction of Big Data technology within the framework of reorganization of the crisis-based business strategy of the logistic company may relate to three directions (and such taxonomy does not mean that one should be limited to one direction):

1) increase of operational efficiency (optimization of operational activity of the logistic company). This direction of using technologies Big Data gives the first results after the implementation of automated processing online of all available data streams.

1.1) In turn, this direction has several applications. In particular, a new approach to organizing a transport task solution for each specific vehicle is proposed, which provides 24/7/365 coordinated dynamic optimization of the sequence of destination points and the route of a particular vehicle, taking into account current traffic data, customer status, the state of the environment, data streams from available sensors.

1.2) Also, the use of Big Data technologies to predict and plan logistic capacities (quantity and volume of warehouses, distribution centers, number of vehicles and their type, etc.) is effective both at the strategic level of management and on the operational one. At the strategic level, such optimization increases the efficiency of investment in logistic infrastructure, taking into account not only accumulated historical time series on traffic flows and volumes, but also taking into account regional and sectoral forecasts, while simultaneously providing more operational responses to unused logistic capacities through dynamic pricing mechanisms and / or spot market of logistic facilities.

1.3) It is clear that at the operational level, the application of Big Data technologies is effective for dynamic scheduling of logistic capacities in 24/7/365 mode. The classic approach to such planning (capacities for storage and transportation of cargoes, the required number of personnel employed, etc.) envisaged the study of historical time series and was based on the subjective experience of the logistic manager. However, only the use of Big Data technology (using streaming data from all available sensors installed on vehicles as well as in warehouse and transshipment infrastructure) combined with Data Mining algorithms will make it possible to build and use prognostic models for efficient and adaptive operational scaling of logistic capacities, with what, given the impact of identified ad-hock restrictions (natural weather phenomena, civil protests, regional and sectoral economic crises, sanctions and other force majeure phenomena).

2) increase the efficiency of CRM, which manifests itself in several functionalities.

2.1) This is, in particular, the monitoring and maintenance of customer loyalty – the use of Data Mining for an integrated analysis of all available internal and external, structured and unstructured data (detailed operational data on the quality of the logistic company work itself, available competitor data, sectoral and regional indicators, social data networks and rating and informative agencies, stock quotes, forum information and electronic boards, etc.) to identify customers who lower the level of loyalty to provider of logistics services and to take marketing proactive counter measures.

2.2) It is also worth noting the importance of using the Big Data technology in monitoring 24/7/365 on compliance with TQM requirements. The results of such monitoring, after searching for them in accordance with the methods of Data Mining (text mining, multimedia mining, SNA, fraud detection), can be used to improve CRM and TQM policies.

2.3) Monitoring the risks of supply chain continuity in Fraud Detection mode involves the use of Big Data technology in monitoring mode 24/7/365 to measure and forecast the risks of delays in delivery, loss or damage to goods, seizure of vehicles or their arrest on the

part of objective (natural phenomena, macroeconomic crises, civil protests) and subjective factors (litigation, harassment, criminal acts) and the rapid adoption of proactive countermeasures.

2.4) In addition to the above, such functions of using Big Data technologies in the field of CRM as more detailed and deterministic segmentation of the client base, automated adjustment of personal discounts should be noted.

3) A new value added generation center for the logistic company, that is, additional revenue from sales to third parties, such as the collected detailed and spatially-bound big data and so the results of their processing and analysis (usually taking into account legal restrictions and possible reputational losses of privacy breach personal data).

3.1) In particular, by ordering small and medium-sized merchant companies, using the detailed, spatially-attached multi-attribute data for postal items and other goods collected during many years of its logistics, the logistic company, after the corresponding DM, can significantly improve the accuracy of forecasting demand and sales in trade.

3.2) In addition, financial analysts, rating agencies and advisory companies in the banking and insurance sectors often need access to the logistic chains supplied by the logistic company with detailed, spatially-linked multivariate data for both their own forecasting purposes and for the purpose the verification of the forecasts provided to them, concerning the volumes and geography of sales and the share of the market of joint stock companies whose shares / bonds are traded on exchanges.

3.3) Regarding e-commerce, an important optimization task is the verification of the shipping address that can perfectly be performed by the logistic company's vehicles, which are additionally equipped with sensors and trackers. This functionality is particularly important in areas with a low population density, which allows optimizing logistic costs through optimal geocoding for the retail, banking and public sectors of the economy.

3.4.) In the field of environmental management, logistic companies, in cooperation with local authorities, equipping their vehicles with a combination of different types of air pollution, temperature, ash, humidity, noise, ozone, etc. – which are tied to geolocation data – are attractive for local authorities, local developers and environmental monitoring bodies.

Further, the text will outline the results of research on the effective use of Data Mining technology as a key factor for the effective implementation of the 8th and 9th steps of the above comprehensive policy of optimizing logistic domestic business.

Thus, in addition to the above mentioned Big Data impact, another factor complicating the analytics of modern logistic data is that most of the logistic data stored in the DBMS, and even more streaming, have the nature of spatio-temporal rows (*Shekhar, 2011*), hence the urgent need is not only in the classical statistical analysis of multidimensional time series, but also the need to find hidden unknown laws and the subsequent construction of predictive spatial models.

That is, taking into account the above-described specificity of the subject area, it can be argued that the classical function of regression, factor, dispersion analysis in today's crisis conditions for domestic logistic companies is not enough.

After all, in order to formulate new prerequisites for the adoption of effective managerial (including anti-crisis) decisions, new, objective knowledge about the hidden essence, connections and regularities of the subject domain is needed. Finding and verifying (including during the classical statistical analysis) actual facts and hypotheses in the database or data warehouse are not so difficult, but in today's competitive information economy, we need not just facts, but new, objective laws, verified, interpreted and formalized in appropriate models of knowledge representation (*He, 2013*).

As the main source of such new objective management templates for a logistic company

operating on a risky, corrupt, competitive and crisis domestic market, only intelligent data analysis technology (*Sinn, 2012*) can be used.

Data Mining is the process of identifying in the primary, accrued as a result of the processing of business transaction data, previously unknown or hidden patterns and templates for the purpose of business decisions making.

Taking into account the foregoing, it can be asserted that in modern domestic conditions, the total introduction of adaptive technology of intellectual data analysis (which also has to work in real-time and fraud-detection modes), within the framework of the system anti-crisis policy of the transport and forwarding company – will result in a complex additional optimization of logistic business processes, obtaining additional competitive advantages, and consequently increasing the company's integrated stability.

The study of existing foreign experience in the use of DM (*Rahman, Desa and Wibowo, 2011*) in logistics revealed very limited usage practices (taking into account the above-mentioned topical optimization directions) to address such operational tasks as: traffic management, overload management and traffic overlays, monitoring and management road surfacing, monitoring of sleepy drivers and drivers with signs of intoxication, accident investigation and road accidents, depth-based multidimensional data analysis spatial geo positioning (including electronic maps to clarify), monitoring and identification of data network video surveillance, monitoring of complex data security on the railway, status monitoring and management of service vehicles.

An analysis of the international practice of selecting DM tools in the logistic industry has shown limitation and lack of a scenario approach (hybrid application). In particular, the published results of DM projects in the transport sector (*Der-Horng, Shin-Ting and Chandrasekar, 2004*) have shown the consistent use of tools for multidimensional visualization, cluster analysis (non-hierarchical), and optionally decision tree (in classification mode) or association rules. Additionally, it should be noted that in the overwhelming majority of implemented DM projects, a productive model of knowledge for the formalization of results has been selected that has significant disadvantages (widely described in the literature) and is not universal. The authors recommended when designing and reengineering of logistics information systems to pay attention to hybrid use in the corporate knowledge base of the framed model (to solve managerial tasks of operational management) and a model such as semantic network (for tactical and strategic levels).

Given the above results, it can be argued that such a traditional, non-hybrid use of DM technology, which is focused solely on the level of individual operational-functional OLTP activities, although it yielded some positive effect in the stable conditions of developed countries to the era of Big Data, but to solve the above problems in the crisis conditions of the transport industry of Ukraine – is absolutely insufficient. This is also confirmed by the results of research conducted by European logistic corporations (*SupplayChain247, 2013*).

That is why, the authors suggest that, for the current conditions in Ukraine (analyzed above), the use of algorithms DM and ML, which can collect, analyze and study data – the best solution is not only to factorize individual indicators sensitive to external changes, but also to implement the functional dynamical pricing (the dynamics of which is mainly influenced by the change in demand for logistic services) (it should be noted that the first step towards the formation of such a composite model is to search for a model for forecasting the cost of logistic services). The dynamic pricing model will help you find a balance between competitive prices and costs, between

supply and demand, on the domestic chaotic, inefficient, shadowy and often corrupt market of logistics services.

Another important task of using the DM and ML algorithms is to find the patterns between the accumulated OLTP information in the logistic company's DBMS and: customer profiles, external macroeconomic and regional indicators, seasonality, geolocation data – this will allow, as a result, to construct an adaptive demand forecast model (and therefore supplies for its satisfaction) for a particular logistic company, that is, in the process of accumulation of data about its use and further iterative re-training – the model will increase its accuracy.

The first and main step for the formation of the above-mentioned adaptive models for a particular logistic company is the forecasting of the volume of necessary supplies within the supply chains. In addressing this predictive task, important factors are also reduced costs in the logistic chain and increased customer satisfaction. This task is traditionally a complex nonlinear task for managers, especially for 3pl companies.

Despite the huge amount of research in this area, to date (especially taking into account the above-described features of the domestic logistic market) the following problems remain in the field of economical and mathematical forecasting of optimal stocks:

- existing multi-factor high-nonlinear models – difficult to calculate and optimize;

- there are many qualitative and categorical indicators that are difficult to operate with classical models of stock prediction (recommendations are given below);

- the presence of conditionally constant indicators in the historical data sample, does not promote self-adaptation, especially after the onset of crisis phenomena;

- information on the effectiveness of the practical application of existing stock management models is indirect, hidden, and the collection of such information requires a lot of time and has a low impact;

- classical inventory management models ignore the effects of fuzzy and uncertain factors.

Taking into account the above fundamental problems in the field of

creating prognostic models of inventory management and the above-mentioned domestic sectoral and macroeconomic difficulties, it is proposed to use an improved artificial neural network with reverse error propagation. After all, the classical artificial neural network with back propagation errors has problems such as low convergence, low learning speed (although this factor is not determinative, taking into account the development of multiprocessing and parallel computing), insufficient accuracy of prediction (such a neural network easily and quickly enters the local minimum while studying). In order to to solve the first and third disadvantages, it is proposed to make changes to the classical algorithm for training neural networks with reverse error propagation: use error compensation and a modified formula for calculating the weight of neurons (these results will be detailed in the following publications).

The construction and use (with periodic re-training) of the above models for a particular forwarding company will improve the optimization and planning of volumes of transportation, warehouse stocks, routes, that is, more efficiently distribute all resources of the logistic company, thereby increasing its integral stability in crisis macroeconomic conditions.

During the construction, use and verification of the found patterns in the mode of fraud detection (after conducting DM for logistic processes as such) – an important result will also be the identification of "bottlenecks" of the logistic company (corruption, fraud, irresponsibility, negligence, simply inefficiency in the company) in existing business processes, and hence the ability to rebuild them.

The authors also propose to pay additional attention to the optimization of the marketing policy of the logistic company, in particular to optimize the policy of customer loyalty, which will be an additional anti-crisis measure, in a highly competitive market for

freight forwarding services in Ukraine. In particular, it is proposed to use DM technology within the framework of Direct Marketing realization. Let's detail in a functionally-algorithmic section the proposed hybrid solutions: segmentation of the client base is proposed to be conducted in parallel with the help of non-hierarchical agglomeration cluster analysis and mapping of Kohonen; the choice of the target audience is proposed to be substantiated by means of DM visualization tools; when formulating address suggestions it is necessary to take into account the results of the construction of the rules of association; when analyzing customer reviews, it is important to use decision trees and classification rules; an assessment of the effectiveness of the loyalty program should be performed with the hybrid use of statistical and RFM analyzes.

It is clear that the entire spectrum of the above recommended DM tools should not completely replace, but organically supplement the classical, but reorganized OLTP and OLAP processing services of the logistic company information, which is coordinated between the front- and back-office.

It should be noted separately that the resulting laws in order to form the corporate knowledge bases of real logistic companies should also take into account the macroeconomic, regional and sectoral uncertainty of the Ukrainian logistic market, therefore, the authors suggest to use fictitious product rules tools for knowledge base formation of a logistic company (of course, after verifying the results of DM).

For the effective DM on logistic data, it is recommended to categorize and encode the attributes that have the type of float data) and for which the range of values is sufficiently large (for example, the weight of the load, the length of the route, etc. As such attributes actually have very many, often unique values, then as a result of the search for regularities (for example, the rules of the association) a lot of patterns will be generated, but with little statistical support. That is, the scale of measurement for the selected attribute is divided at intervals in which all the faces attribute values are compared for DM goals. So it is recommended by the authors to use the results of non-hierarchical cluster analysis to split the scale.

In addition, on the basis of the previously described by the authors in the publication of the results of studies on the macroeconomic, sectoral and temporal-cyclic specifics of the current state of the subject area, the use of the DDDM-Knowledge AKD standard in DM projects for domestic logistics companies is recommended.

Also, in the study of the methodology of implementing DM technology in logistic business processes, it is worth noting that there is an obvious lack of standardization in the industry, in the areas of collection and storage of all types of functional data for routes, projects and companies. That is, there is an urgent need to develop a unified data model for logistic data on the acceptance. This data model should be organized in the form of four interconnected layers: the data layer of the transportation route; the data layer of the logistic company; customer data carrier layer; a layer of regional and sectoral macro data. The adoption of such a unified model of logistic data will not only facilitate the rapid implementation of machine learning algorithms and AI elements in the practice of adaptive logistic information systems, but will also increase their accuracy and quality.

Within the framework of the above-mentioned methodology for the use of Data Mining in adaptive logistic information systems, it is important to take into account the restrictions on the use of real stream logistic data:

- required expert knowledge of the chosen field of logistics for the evaluation and interpretation of Data Mining results;
- the results of the intellectual analysis

depend on the a priori assumptions, the configurations of the selected methods of Data Mining;

- complexity with the preparation for the analysis of qualitative (categorical), fuzzy attributes;

- within the framework of Data Mining, there is no universally accepted approach to selecting relevant attributes (inclusion of a large number patterns of non-relevant attributes in the search algorithm may cause incoherency of the results, and the expert substantial limitation of the number of attributes prior to the search of the laws conflicts with the main goals of Data Mining).

It is also advisable to outline the results of the study on the peculiarities of the organization of business processes that affect the effective reorganization of the logistic company into an intellectualized / knowledge-based company:

- within the conceptual phase of each Big Data project and Data Mining it is necessary to consider the issues of protection of personal data and their confidentiality. In particular, personal data is often disclosed in the search for new potential customers of a logistic company. It's worth noting that not only the privacy laws are restrictions (in particular, taking into account the agreement on the association of Ukraine with the EU and the volume of foreign trade of Ukraine with the EU – it is important to take into account the EU General Data Protection Regulation), but also public opinion and public debate on violations of the privacy of personal data by the logistic company can cause a catastrophic fall not only in corporate reputation, the capitalization of the brand, but also the volume of sales and profitability;

- synchronization and coordination between the business and IT divisions of the logistic company in planning, developing, realization and monitoring the implementation of the complementary concepts of Big Data and Data Mining;

- regular investments not only in the hiring of highly educated and experienced IT personnel, but also in training and advanced training of their own, concerning the taxonomy of scenario use of algorithms and DM methods. After all, in order to effectively solve a specific problem in a particular logistic company, optimal and personalized hybrid scenario of application of algorithms DM & Big Data is necessary;

- control and ensure verifiability, quality, transparency and efficient data management, since the concept of Big Data provides an intelligent analysis of the combination of autonomous data streams. That is why: it is necessary to localize data and metadata arrays; to avoid ambiguity in data, data attributes should be clearly structured and clearly identified with verification in several databases; to detail and enhance the quality management of Big Data, since the use of DM technologies for incomplete, outdated, duplicate data from standalone sources, with parallel consideration of trends to increase their speed, volume and format, dramatically complicates the validation and configuration procedures;

- effective use of Data Mining for the innovative Big Data solutions, taking into account their disadvantages and limitations, including distributed and parallel computing, In-Memory Data Grid.

6. Conclusions.

In the article, based on the study of the international experience of 3PL companies, based on the domestic national, industry specific and taking into account the current Ukrainian political and macroeconomic crisis, the results of research on the development and configuration of a comprehensive logistic business optimization policy (consisting of 9 detailed stages) are presented as an integral part of systemic anti-crisis measures.

Taking into account the specialty chosen by the authors (Mathematical methods, models and information technologies in the economy), within the framework of which scientific research is carried out, special attention is paid to optimization of information management of the logistic company (the 8th and 9th stages within the framework of the above-mentioned

policy of optimization of a logistic business) with the use of innovative technologies of Big Data and Data Mining.

In particular, the practical experience in terms of functional tasks and algorithmic support for the use of Big Data and Data Mining technologies by international logistics companies has been researched, the problem issues have been identified and appropriate recommendations for domestic logistics companies have bee given.

In addition, as part of the development of a comprehensive methodology for hybrid application of Big Data and Data Mining technologies (within an adaptive logistic information system), the following results are also outlined:

- the choice and configuration of the model of presentation of knowledge is substantiated;

- a scripted approach to using the recommended Data Mining algorithms is configured;

- effective modes of search of regularities are recommended;

- formulation and detailing of the important for construction of the adaptive forecast economic and mathematical models (taking into account the implementation of the anti-crisis optimization policy) for the logistic company were completed;

- taking into account the results of the analysis of problems in the field of economical and mathematical modeling of logistic activity, the configuration of effective tools for solving such predictive models is recommended (BP neural network with error compensation and modified weighting formula);

- on the basis of the results of the analysis of the specifics of the subject area data (including stream), are given recommendations for modifying the scales of the attributes of "float" type in order to improve the quality of the results of the processes of Big Data and Data Mining;

- recommendations for the universal metadata format for Big Data and Data Mining projects are given;

- the importance of changing the typical standard of Data Mining CRISP-DM on DDDM-Knowledge AKD is substantiated;

- the results of the study on the peculiarities of the organization of business processes that influence the effective reorganization of the logistic company into the intellectualized / knowledge-based company are presented.

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