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Development of Process-Oriented System For Operational Control of Freight Forwarding Activity

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Abstract: A scientific approach to develop a unified control system for Freight Forwarding Activities (FFA) is proposed and substantiated in this study. It is based on the information systems used to improve the efficiency and manageability of freight forwarding companies. A mathematical model for calculation of plan indicators for the process management purposes in freight forwarding activities is developed together with a method to create a system of control procedures and an algorithm of control and elimination of incidents, integrated into the Managerial Decision Support System (MDSS). The proposed system of control allows determining the optimal parameters of a transport chain taking into account the specifics of each transaction and particular conditions of carriage in close connection with the environmental parameters and management objectives of the company. The set of scientific principles, ideas and practical results of research, developed methods and algorithms have been tested and implemented for practical application in the Association of International Road Transport Carriers (ASMAP) and BDP International.

Key words: Freight forwarding activity, freight forwarding companies, road transportation, information systems, decision support systems, operational control, process approach

INTRODUCTION

The main criterion for survival of Freight Forwarding Companies (FFC) is to maintain a high competitiveness which is impossible without a search for new business opportunities. Promoting business in large uncertainty conditions defines an operational nature of a company's activity. The substantial information distortions and the largest number of risks associated with failures in the realization of management tasks arise at this stage.

One of the obstacles for the development of freight forwarding companies is quality of management. A key process is a control which, if realized, allows providing feedback and making optimal management decisions. It is especially crucial to establish a system of the organization control in the process management conditions. In a relatively short period it gives an opportunity to get reliable and good quality information in a transport chain and to regulate resource load.

The existing methodological approaches to the problem of stability of the FFC activity consider only particular aspects. However, the multidimensional nature of the problem suggests considering in a new fashion of the creation principles of control management functions. Today they do not disclose the relationship with the management process and evaluation of the company's effectiveness which leads to a decrease in the management significance. Namely this causes the need for scientific base of raising the control system importance in freight forwarding activities.

MODERN TRENDS IN DEVELOPMENT AND MANAGEMENT FEATURES OF FREIGHT FORWARDING COMPANY

The freight forwarding activity represents a set of organizational and technological interrelated activities and operations performed by the FFC and their departments independently or in agreement with other organizations for preparation, realization and completion of goods transport. The structure of freight forwarding activities includes:

- Management of carriers traffic
- Coordination of work for different types of transport
- Selection of the type and determination of the rolling stock necessary for transportation
- Rating of traffic speeds

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- Feasibility determination for using different transport types depending on the specific conditions of transportation, the type and nature of goods, the transport performance indicators
- Ensuring efficient and secure transportation of goods
- Operational control of the transportation process
- Use of economic-mathematical methods and calculations to improve the efficiency and reduce the cost of transportation
- Development of cargo flows on the basis of surveys: The rational route schemes that foresee changes in the directions of the existing and opening of the new routes

A considerable number of studies is focused on addressing issues on improvement of the organization and management of a freight forwarding company in market conditions, as well as on the management and control issues in order to make the optimal management decisions (Krupensky, 2010a-c, 2011, 2012; Ivakhnenko and Krupensky, 2012).

Krupensky (2010a-c, 2011, 2012), Ivakhnenko and Krupensky (2012) and Nikolaev and Ostroukh (2013) contained specific recommendations for optimizing the operation and interaction of different types of transport and organization of cargo transportation in international communications.

Studies of information support for freight forwarding activities, including the development of algorithms for automated design of information processes to improve the management efficiency, are deeply discussed by Krupensky (2010a-c, 2011, 2012), Ivakhnenko and Krupensky (2012), Ostroukh *et al.* (2010, 2013), Surkova and Ostroukh (2004) and Nikolaev and Ostroukh (2013).

A standard organizational management system of a freight forwarding company at current activity is mainly considered. The managing issue of the freight forwarding company at operational activity does not practically rise. The use of existing IS to support the operational decision-making is not explored enough. With increasing amount of information there are also insufficiently mature issues of using those control methods in freight forwarding activity that are used in other types of activities.

Coordinated integration and accomplishment of management processes in transport services naturally provides more efficient management. The quality management methodology known as "Plan-Accomplish-Control-Act" can be applied to almost all the processes in freight forwarding activity:

- Plan, establish the objectives and processes to produce the results that meet customer requirements
- Accomplish, carry out these processes
- Control, monitor and measure the processes and services with respect to the policy, objectives and requirements
- Act, take actions to continually improve process performance

A key process is the process of control which aims to measure and audit in order to confirm that the objectives of management service are achieved and the plan is executed. The goals of management service audit have to be registered and then the necessary correction actions to be defined. Information about significant discrepancies should be brought to the attention of interested parties. In order to improve the efficiency of transport services all the proposed improvements should be ranked by priority and assigned to the responsible executives.

The existing automation solutions (Krupensky, 2010a-c, 2011, 2012; Ivakhnenko and Krupensky, 2012; Ostroukh *et al.*, 2010, 2013; Surkova and Ostroukh, 2004; Nikolaev and Ostroukh, 2013) can solve many problems of FFC, including analyzes of discrepancies between the planned and actual indicators using temporal, quantitative and financial gauges; but they are expensive and "heavy" as SAP and therefore, not suitable for small and medium businesses. They can also be cheap enough and comfortable, carrying a continuous process monitoring and accounting functions and being not specialized for the analysis of the processes in real time. Some part of the software products requires in addition a complex development in order to adapt the system to the needs of the organization. The other part is used only to organize the activity of one type of transportation. The Information System (IS) should not just generate reports containing an assessment of the achieved results, but also detect exceptional situations that require a special attention. There appears a need to use new features of company management through the introduction of control subsystem into the information systems.

MODELS AND METHODS

The scheme of management and control of freight forwarding activity can be represented in a form of "Management loop", including a cyclic sequence of the following stages: Prediction, planning, activities for realization of plans, account and analysis of the results, correction of the predictions and plans.

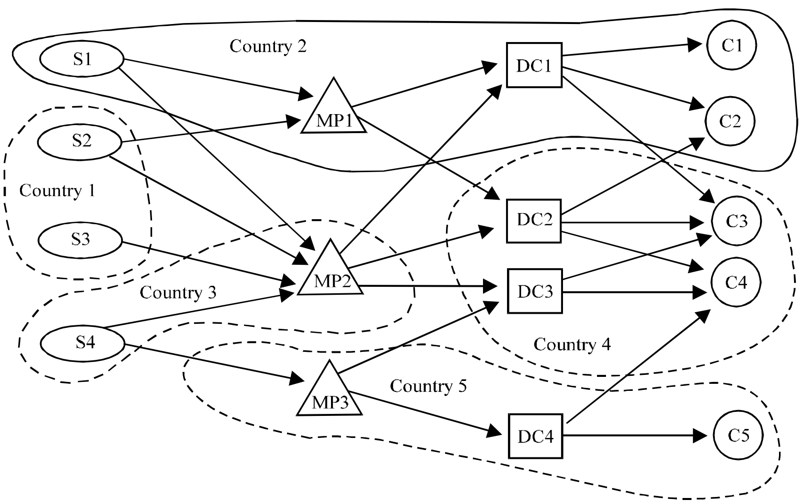

Fig. 1: Logical scheme of interaction

The key role in the management and control system is played by the information support. For implementation of control functions it is necessary that the information flow goes ahead of a material flow or corresponds to it. To assess the management efficiency of transport flows, a choice of key indicators on the basis of key purposes is proposed.

A mathematical model is necessary for calculating the plan indicators in order to determine their value based on the predicted demand on transportation services. To create the mathematical model, a logical scheme of interaction is considered (Fig. 1).

The following parameters are entered into the model: c_i: Freight cost for the i-th period, E_i: Cost of the order for the i-th period, h_i: Specific expenses during the considered I-th period, u_i: Specific losses for the i-th period, r_i: Specific income for the i-th period, α_i: Discounting coefficient for the i-th period, D_i: Value of the casual order for the i-th period, $f(D_i)$: Probability density D_i for the i-th period.

We consider m_n orders, where n is the number of periods. Let $F_i(x_i)$ be the maximum total expected profit for the orders from i to m_n, where, x_i is a transport reserve before placement of the i-th order. To solve this problem we will use Bellman's principle of optimality. The condition of system in terms of the order of y_i units of transport depends on the cost of freight, cost of the order, specific expenses, etc. The management on each step has a choice whether to take the order and for what quantity of transport units, or not.

The first two sampling points of number of possible orders are the unbiased estimates of the mean value and variance, respectively and are the first two Fisher's k-statistics, where k_1 and k_2 are n-dimensional vectors:

$$k_1 = \int_{-\infty}^{\infty} (DF(D))dD,\ k_2 = \int_{-\infty}^{\infty} \left[\left[(D^2\right]\right] f(D))dD \quad (1)$$

In this task n samples of normal set, i.e., from $N(k_{11}, k_{21}), \ldots, N(k_{1n}, k_{2n})$ are considered. Thus:

$$N\left(\sum_{i=1}^{n} b_i\, k_{1i}, \sum_{i=1}^{n} \frac{b_i^2\, k_{2i}}{m_i}\right) \quad (2)$$

where, b_i are some constants.

Let us write this task in a form of dynamic programming task:

$$F_i(x_i) = \max_{y_i \geq x_i} \left\{-c(y_i - x_i) + \int_0^{y_i} (rD - h(y_i - D))\, f(D)dD + \int_{y_i}^{\infty} (ry_i - ar\ (y_i - D))\right. \quad (3)$$

As the function of expected profit $F_i(x_i)$ is concave, the optimal solution can be determined from the condition in which the equation is written in a vector form (from R^n):

$$\frac{\partial F}{\partial y} = -c - h \int_0^{y_i} f(D)dD + \int_y^{\infty} ((1-\alpha)r + u)f(D)dD + \alpha\int_0^{\infty}\left(\frac{\partial F(y-D)}{\partial y}\right) f(D)dD = 0 \quad (4)$$

where, the value:

$$\left(\frac{\partial F(y-D)}{\partial y}\right) = c$$

is defined as follows: If for the beginning of the following stage there are still orders, the profit will increase by a value proportional to them and the volume of the following orders will decrease by the same amount:

$$-c-h\int_0^y f(D)dD+((1-\alpha)r+u)\left(1-\int_0^y\left[\!\left[f(D)dD)+ac\int_0^\infty f(D)dD=0\right]\!\right]\right) \quad (5)$$

Therefore, the optimal level of order y^* is obtained from the equation:

$$\int_0^{y^*} f(D)dD=\frac{u+(1-\alpha)(r-c)}{u+h+(1-\alpha)r} \quad (6)$$

Having x_i reserve units, the optimal strategy for every stage is expressed as follows: If $x_i<y_i^*$, then do take the order in the amount $z_i = y_i^*-x_i$ units, otherwise do not take the order ($z_i = 0$). The corresponding function of production costs for i-th stage is:

$$c_i(z_i)=\begin{cases}0, & z_i=0\\ E_i+c_i(z_i), & z_i>0\end{cases} \quad (7)$$

The main goal is to obtain the information with the help of sampling method. Based on this information one can make some statements or draw conclusions on the F(x) or some of its properties. For its creation, limitations on the first and second-order moments k_1, k_2 are sufficient.

Let us consider a sample D = (D1, D2,…, Dn) with a distribution $N(k_1, k_2)$ and obtain its interval estimates. As the value:

$$\frac{\sqrt{n}\left(\bar{D}-k_1\right)}{\sqrt{k_2}}$$

on the interval $[t_1, t_2]$ obeys Student's distribution, then:

$$p\left\{t_1<\frac{\sqrt{n}\left(\bar{D}-k_1\right)}{\sqrt{k_2}}<t_2\right\}=\gamma \quad (8)$$

Thus:

$$\bar{D}-t_2\sqrt{\frac{k_2}{n}},\ \bar{D}-t_1\sqrt{\frac{k_1}{n}}$$

is an observed random confidence interval with probability γ. The confidence interval with $\gamma = 0.95$ is most often considered. For the evaluation of plan results their mean values in the regression analysis are given by regression function:

$$G(y_i)=\sum_{j=1}^n \beta_j x_{ji}$$

As a result of estimate of the parameters βi and taking into account that:

$$G^{-1}(\beta_j)=\sum_{i=1}^n a_{ij}y_i$$

We obtain:

$$G(G^{-1}(\beta_j))=\sum_{j=1}^n\sum_{i=1}^n \beta_j a_{ij} y_i$$

From this it is clear that the a_{ij} must fulfill the condition:

$$\sum_{r=1}^n a_{jr}x_{ir}=\delta_{ij}$$

where, δ_{ij} is the Kronecker symbol. Thus, according to Gauss-Markov theorem, the estimate with minimum variance for β_i is:

$$\beta j=\sum_{i=1}^n\left(\sum_{r=1}^n x_{ir}\,x_{jr}\ \sum_{r=1}^n x_{ir}\,y_r\right) \quad (9)$$

In systems based on the exchange of information, it is useful to distinguish two types of organizational elements: Those that include the core activities and those that do not. The elements of the first type are (final) consumer-information providers and can interact both directly (providing information activities in their own organizational framework) and by means of the elements of second type. The latter are intermediate consumers-information providers or information systems.

A general idea about interaction of the users of data exchange system is shown in Fig. 2.

In this representation the interaction levels are divided into three types:

- Direct working interaction (link 3-3) is a constant exchange of information in a group or team in the joint venture
- Direct documentary interaction (link 4-2) is making the result and its restricted and controlled spread (e.g., delivery of a report or documentation to the customer)
- Documentary mediated interaction (link 5-1) is the publication of result and its subsequent unrestricted spread via IS

The management of information exchange (information resources) at the macro level can be divided into:

- Organization of work and interaction of agents and subcontractors realizing processes of freight forwarding activities (link 3-3)
- Marketing-search for customers, receipt of orders, communication with customers, processing and transmission of the results, search for other possible consumers of the results (link 4-2)
- Spread of the information in documentary form via IS, solving the tasks of improving the completeness, accuracy, efficiency of information exchange and service (link 5-1)

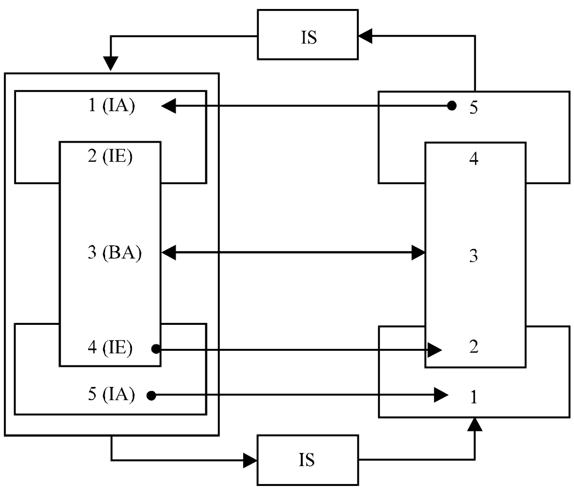

Fig. 2: Levels of consumer-information provider interactions, IA: Information activity, IE: Information exchange, BA: Basic activity and IS: Informations system

Further, the study realizes a method of management solution choice in the information graph, the algorithm for a general problem of traffic management. The definition of Information Graph (IG) over the base set IG = <W,V> is given in Fig. 3.

We consider a finite multipole oriented network. In the diagrams it is represented as point-poles some of which are connected by lines. The root pole is selected. The remaining poles are leaves and some records from the set Z are assigned to them and besides various leaves can be assigned to the same record. Some vertices of the network (including the poles) are switching ones and they got assigned switches from the $V = \{v_i,\ i \in I\}$. Edges coming out from each of the switching vertices are numbered in succession starting with 1 and are the switching edges. The edges which are not switching are predicate and they got assigned predicates from the set $W = \{w_j,\ j \in J\}$.

The loaded multipole oriented network over the base set IG = <W,V> is the Information Graph (IG). In this case $V = \{v_i,\ i \in I\}$, $W = \{w_j,\ j \in J\}$, where, I, J are finite sets of indices. The algorithms of block diagrams given in this study are implemented using IG.

To create and implement the information graph, a concept of the Information Search Problem (ISP) is introduced. In this study, the ISP is given as follows:

- On the basis of information received from the system control procedures described above, such as, for example, "Checking the time of signing a contract", "Calculation of risks", "Checking the Price of Order" and others, a library is formed (the set of records for search using a key)

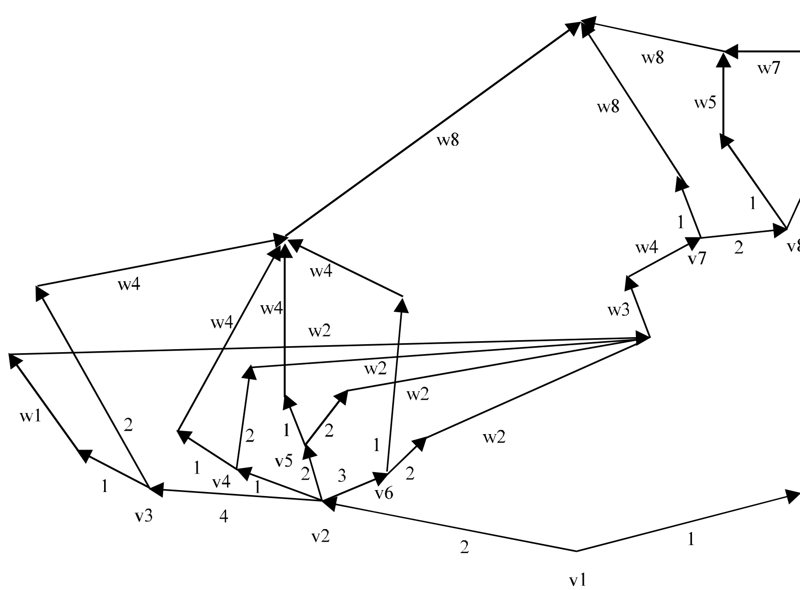

Fig. 3: Information graph of control system

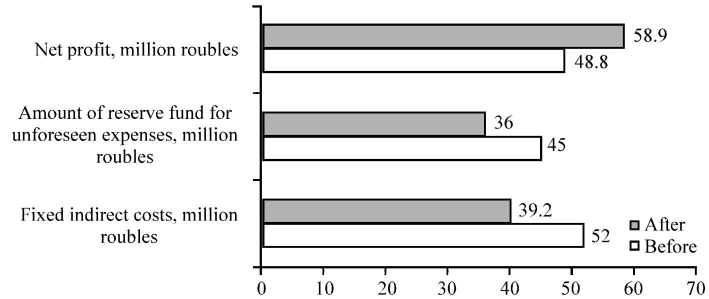

Fig. 4: Efficiency of using control system

- Customer creates a key-inquiry for the search, i.e., a list of wishes for the future order is compiled
- Management of the order selection is transmitted to the module-algorithm, i.e., the described mathematical model is realized. It gives the final result in a form of recommendation to sign the contract for this order

ISP in action is a triplet $S_z = (X.Y.\rho)$, where, X is the number of requests, Z is a subset of set Y (or BD-block diagram), ρ is the search ratio. Thus, the concept of ISP is formalized.

The next step is to choose a model for the search algorithm. Let us consider an arbitrary ISP $S_z = (X.Y.\rho)$. It is considered that the search algorithm solves ISP if for any inquiry from the multiple inquiries X it gives all those and only those records from Z, which satisfy the inquiry. Let us take any entry z∈Z and introduce a characteristic function for it:

$$X_{z,\rho}(x) = \begin{cases} 1, \text{ if } x\rho z \\ 0, \quad \text{otherwise,} \end{cases} \tag{10}$$

It means that the function equals to 1 for those inquires, that satisfy the entry z. One can argue that the algorithm that solves ISP $S_z = (X.Y.\rho)$, where, $Z = (z_1, z_2, ..., z_k)$ is nothing else but the algorithm that realizes the system of functions $(x_{z1,\rho}, x_{z2,\rho}, ..., x_{zk,\rho})$. Therefore, the management system that simulates the algorithm solving ISP $S_z = (X.Y.\rho)$ should be a multipole that realizes a set of characteristic functions $(x_{z1,\rho}, x_{z2,\rho}, ..., x_{zk,\rho})$.

The described network, operation of which solves the problem given in this study, is a special case of the information graph.

Thus, the mathematical model allows us to control, predict and determine the volume of traffic while the information graph allows assessing the complexity of the information system and its performance.

RESULTS AND DISCUSSION

Indicators of the Net Present Value (NPV), Internal Rate of Return (IRR), reduced pay-back period (Pay-back Period), payback period (T) and Return of Investment (ROI) are used for the evaluation. If the value of ROI <20%, the investments made into the project are ineffective. "Aggressive" companies should focus on the ROI of about 150-300%. However, any positive NPV is considered as a good indicator of the effectiveness of the project.

The calculation was made on the basis of statistical data of the Czech branch of the company BDP International, where the implementation of control system had being performed. In Fig. 4, the company's economic indicators obtained using both the existing software and the implemented integral control module are presented.

Based on the calculations, the payback period of the project was about 4 years. Indicator of the project investment efficiency ROI was 207%, the increase in net profit is 305.4 thousand dollars, the net present value NPV is 5.26 and the profitability is 24%. Calculation result showed that this investment project is cost-effective. The quality of information, its reliability and accuracy are also improved. Processing time gets reduced; the required level of safety is provided. As a result, the level of information management gets increased.

CONCLUSION

The authors believe that the monitoring system has a systematic approach to solving the problems of development and functioning FFC, will balance its activities and helps identify the main lines of its development. Sense of control is detected in the implementation and management objectives is to improve its methods for solving the basic problems while optimizing FFC activities in general.

To summarize, it can be noted that the control system performs the function of pre-emptive actions and sets the level of operational management processes on the level of significance. Such information-analytical value control system helps to identify weak links in the transport chain, neutralizing the level of uncertainty. From providing full control depends on the formation of a modern, efficient transport policy of the enterprise. The system provides the ability to quickly assess the results and allows qualitatively improve the manageability of the enterprise.

The authors hope that the findings and proposals presented in this study will be useful and will have a positive effect on the development of FFA.

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