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5 MODELING OF TRANSPORT LOGISTICS DURING THE PERIOD OF SPECIAL LEGAL REGIME

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ABSTRACT

The problems of relocation of high-tech enterprises, cargo and people under martial law, as well as optimization of supply of components after changing the location of production, are studied.

Logistics planning models are proposed that take into account the risks caused by military actions, disruptions of transport chains and resource shortages.

The key stages of relocation are identified: selection of a safe location, adaptation of logistics infrastructure, establishment of new supply channels.

Factors affecting the supply of components are analyzed, in particular the availability of transport corridors, ensuring the stability of supplies and minimizing transportation costs.

It is determined that effective modeling of relocation processes and supply logistics is an important factor for maintaining the competitiveness and stability of high-tech enterprises during crisis situations.

KEYWORDS

Relocation of enterprises, martial law, high-tech production, supply of components, logistics of the crisis period, supply optimization, logistics modeling, transport chains.

5.1 MODELING OF RELOCATION LOGISTICS OF HIGH-TECH ENTERPRISES IN THE CONDITIONS OF MARTIAL LAW IN THE COUNTRY

The special legal regime of the country forced to review the logistics processes of transportation [1–6]. New directions in logistics have appeared, which need to be explored for effective planning of transportation in conditions of military threats.

The logistics of transportation of industrial cargo to the rear has its own characteristics [7, 8], which are associated with the movement of enterprises from the frontline zone to a relatively safe location, to establish the production of high-tech products, including weapons and military equipment. Transport routes are formed in advance and are associated with the choice of the location of the enterprise. The choice of location depends on the availability of supporting infrastructure, energy supply, remoteness of suppliers of components, as well as the availability of qualified personnel [9]. Therefore, it is necessary to take into account a number of factors when locating an enterprise in conditions of military threats [10, 11]. Transport logistics should contribute to the efficiency of the enterprise relocation and the formation of new routes for the supply of components for the stable functioning of high-tech production, in conditions of martial law. To assess the possible and rational routes for moving goods of a high-tech enterprise, it is necessary to form logistics indicators of transportation taking into account the risks of military threats [12]. It is advisable to use the following logistics indicators:

1. The time required to move the enterprise from the frontline zone to the rear (transportation of technological equipment, building structures, etc.) – *T*.

2. Costs for relocation of the enterprise to the rear – *V*.

3. Risks of transporting goods, with the enterprise's technological equipment, in conditions of military threats – *R*.

When modeling the relocation of the enterprise, from the frontline zone to the rear, it is necessary to take into account the available opportunities for choosing a relatively safe location for the enterprise, as well as possible routes for transporting technological equipment, in conditions of military threats.

To form optimization models regarding the relocation of an enterprise under martial law, let's introduce a Boolean variable x_{epl}:

$$x_{epl}=\begin{cases}\text{1, if for the relocation of the enterprise}\\ \text{to } e\text{-th possible location the } p\text{-th way for transportation of}\\ \text{goods with technological equipment is chosen}\\ \text{with } l\text{-th possible composition of logistics components}\\ \left(\text{temporary storage city, transshipment, parking areas, etc.}\right);\\ \text{0, otherwise.}\end{cases}$$

Then, taking into account the variables x_{epl}, let's present the logistics indicators of the enterprise to the rear in the form:

$$T=\sum_{e=1}^{M}\sum_{p=1}^{m_e}\sum_{l=1}^{n_p}t_{epl}x_{epl}, \tag{5.1}$$

where *l* – the number of possible location of the enterprise when it is relocated to the rear; m_e – the number of possible ways of moving the enterprise to *e*-th new location; n_p – the number of possible compositions of logistics components that can be used on the *p*-th way of moving the enterprise; t_{epl} – the time required to relocate the enterprise to the rear when choosing the *e*-th location, the *p*-th way of movement and the *l*-th composition of logistics components.

$$V=\sum_{e=1}^{M}\sum_{p=1}^{m_e}\sum_{l=1}^{n_p}v_{epl}x_{epl}, \tag{5.2}$$

where v_{epl} – evaluation of the costs that are necessary for the realization of the enterprise with moving it to *e*-th location, taking into account the choice of the *p*-th path of movement and the *l*-th possible composition of logistics components.

$$R=\sum_{e=1}^{M}\sum_{p=1}^{m_e}\sum_{l=1}^{n_p} r_{epl}x_{epl}, \tag{5.3}$$

where r_{epl} – the risk that is associated with the possible occurrence of a military threat in the relocation of the enterprise, taking into account the choice of the e-th location of its location, the p-th way of movement and the selected l-th composition of logistics components.

In the state of martial law, it is extremely important that the enterprise's relocation to the rear is carried out in the shortest time, which is related to the possible actions of military threats and the need for faster production of weapons and military equipment (WME).

Therefore, as the main logistics indicator let's use the time of movement of the enterprise (T), which must be minimized. Let's optimize with the use of integer (Boolean) programming. It is necessary to find:

$$\min\ T,\ T=\sum_{e=1}^{M}\sum_{p=1}^{m_e}\sum_{l=1}^{n_p} t_{epl}x_{epl}. \tag{5.4}$$

It is necessary to take into account the possible risks of action of military threats that arise when moving the enterprise to a new location:

$$R\le R^{*},\ R=\sum_{e=1}^{M}\sum_{p=1}^{m_e}\sum_{l=1}^{n_p} r_{epl}x_{epl}, \tag{5.5}$$

where R^{*} – the permissible risk of military threats in the relocation of the enterprise.

Also, it is necessary to consider the possible cost of relocation of the enterprise:

$$V\le V^{*},\ V=\sum_{e=1}^{M}\sum_{p=1}^{m_e}\sum_{l=1}^{n_p} v_{epl}x_{epl}, \tag{5.6}$$

where V^{*} – the permissible (planned) costs of moving the enterprise to the rear.

5.2 MODELING THE SUPPLY OF HIGH-TECH COMPONENTS AT THE NEW LOCATION OF THE ENTERPRISE

When moving the enterprise to the rear, it is necessary to form the composition of suppliers of components required for the production of high -tech products, including WME. Also, it is necessary to choose rational ways of supplying accessories to a new location of the enterprise.

Therefore, let's form a logistics indicators for analyzing the process of supplying components in the form:

1. The cost of supplying components that depend on the new location of the enterprise, the composition of suppliers and the selected delivery routes – W.

2. The time required for the formation of inventories of components that will ensure a stable functioning of the enterprise at a new location — T.

3. Risks related to the supply of components in martial law — R.

Let's introduce Boolean variable x_{efy}:

$$x_{efy} = \begin{cases} 1, \text{ if for } e\text{-th new location of the enterprise } f\text{-th composition of suppliers and} \\ y\text{-th composition of ways of supplying components are chosen, otherwise.} \end{cases}$$

Taking into account variables x_{efy}, logistical indicators of supply components look like:

$$W = \sum_{e=1}^{M} \sum_{f=1}^{s_e} \sum_{y=1}^{q_f} w_{efy} x_{efy}, \tag{5.7}$$

where w_{efy} — the costs of formation of inventories of components, taking into account the e-th location of the enterprise, the f-th composition of suppliers and the y-th composition of supply routes; M — the number of possible location of the enterprise in the rear; s_e — the number of possible compositions of suppliers of components; q_f — the number of possible compositions of ways of supplying components.

$$T = \sum_{e=1}^{M} \sum_{f=1}^{s_e} \sum_{y=1}^{q_f} t_{efy} x_{efy}, \tag{5.8}$$

where t_{efy} — the time required to form the inventories of components to ensure the sustainable functioning of the enterprise at a new e-th location, taking into account the f-th composition of suppliers and the y-th selected composition of the ways of supplying components to the enterprise.

$$R = \sum_{e=1}^{M} \sum_{f=1}^{s_e} \sum_{y=1}^{q_f} r_{efy} x_{efy} m, \tag{5.9}$$

where r_{efy} — the risk of supplying components in the face of military threats, taking into account the choice of the e-th location of the enterprise, f-th composition of suppliers and the y-th composition supply routes.

In the state of martial law, it is extremely necessary to quickly adjust the work of a high-tech enterprise at a new location. Therefore, as the main, most significant, logistics indicator, let's use the time (T) required to form the inventories of components, to ensure the restoration of the enterprise at a new location.

It is necessary:

$$\min\ T,\ T = \sum_{e=1}^{M} \sum_{f=1}^{s_e} \sum_{y=1}^{q_f} t_{efy} x_{efy}, \tag{5.10}$$

taking into account the restrictions:

$$W \le W^*,\ W = \sum_{e=1}^{M} \sum_{f=1}^{s_e} \sum_{y=1}^{q_f} w_{efy} x_{efy}, \tag{5.11}$$

where W^* – the permissible costs for the formation of inventories of components for the sustainable functioning of the enterprise at a new location.

$$R \le R^*,\ R = \sum_{e=1}^{M} \sum_{f=1}^{s_e} \sum_{y=1}^{q_f} r_{efy} x_{efy}, \tag{5.12}$$

where R^* – the permissible risks of supplying components in the face of military threats.

Multicriterial problem is possible to find the rational composition of suppliers and ways of supplying components at the new location of a high-tech enterprise. Let's introduce a comprehensive logistics supply indicator:

$$Q = \alpha_W \check{W} + \alpha_T \check{T} + \alpha_R \check{R}, \tag{5.13}$$

where α_W, α_T, α_R – «scales» of indicators W, T, R.

$$\alpha_W + \alpha_T + \alpha_R = 1, \tag{5.14}$$

where $\check{W}$, $\check{T}$, $\check{R}$ – normalized values of the indicators W, T, R.

$$\check{W} = \frac{W - W_{\min}}{W^* - W_{\min}}, \tag{5.15}$$

where $W_{\min}$ – the minimum cost value.

$$\check{T} = \frac{T - T_{\min}}{T^* - T_{\min}}, \tag{5.16}$$

where $T_{\min}$ – the minimum value of supply time.

$$\check{R} = \frac{R - R_{\min}}{R^* - R_{\min}}, \tag{5.17}$$

where $R_{\min}$ – the minimum value of supply risks.

In order to solve the multicriteria task of searching suppliers and ways of supply is required:

$$\min Q = \alpha_W \check{W} + \alpha_T \check{T} + \alpha_R \check{R} = \frac{\alpha_W}{W^* - W_{\min}} \sum_{e=1}^{M} \sum_{f=1}^{s_e} \sum_{y=1}^{q_f} w_{efy} x_{efy} + \frac{\alpha_T}{T^* - T_{\min}} \sum_{e=1}^{M} \sum_{f=1}^{s_e} \sum_{y=1}^{q_f} t_{efy} x_{efy} +$$

$$+ \frac{\alpha_R}{R^* - R_{\min}} \sum_{e=1}^{M} \sum_{f=1}^{s_e} \sum_{y=1}^{q_f} r_{efy} x_{efy} - \frac{\alpha_{W_{\min}}}{W^* - W_{\min}} - \frac{\alpha_{T_{\min}}}{T^* - T_{\min}} - \frac{\alpha_{R_{\min}}}{R^* - R_{\min}}. \quad (5.18)$$

5.3 DISCUSSION OF THE MODELING RESULTS OF TRANSPORTATION LOGISTICS IN THE PERIOD OF SPECIAL LEGAL REGIME

The study of logistics processes of transportation during the martial law of the country has been conducted. Separate relevant areas of study related to the relocation of high-tech enterprises in the country of martial law, as well as the supply of high-tech components at the new location of the enterprise, have been determined.

The basic logistics indicators have been formed for the necessity of evaluation of the transportation processes in the conditions of military threats (the time required to move the enterprise from the frontal zone to the rear; the cost of relocating the enterprise to the rear; the risks of transportation of goods, with technological equipment of the enterprise, in the conditions of military threats for supply; formation of stocks of components that will ensure the stable functioning of the enterprise at a new location).

Optimization models have been created to choose rational relocation and the supply of high-tech components. Local optimization of logistics indicators, taking into account restrictions, has been carried out. A multicriterial model has been created to find the rational composition of suppliers and ways of supplying accessories at the new location of a high-tech enterprise.

The proposed approach is the basis for the creation of applied information technology for planning logistics of transportation, taking into account possible military threats during the martial law of the country.

REFERENCES

1. Fedorovych, O. Ye., Zapadnia, K. O., Ivanov, M. V. (2016). Using the precedential approach for action plan formation for increasing competitiveness of developing enterprise. Radioelectronic and Computer Systems, 1 (75), 114–118.
2. Fedorovych, O. Ye., Pronchakov, Yu. L. (2020). Method to organize logistic transport interactions for the new order portfolio of distributed virtual manufacture. Radioelectronic and Computer Systems, 2 (94), 102–108. https://doi.org/10.32620/reks.2020.2.09
3. Fedorovych, O. E., Slomchynskyi, O. V., Puidenko, V. A. (2018). Investigation of logistics to manage high-tech technology production of virtual enterprise. Aerospace Technic and Technology, 4, 107–115. https://doi.org/10.32620/aktt.2018.4.13

4. Fedorovych, O. E., Haidenko, O. A., Puidenko, V. A. (2017). Planning of cargo transportation in terms of high risks. Aerospace Technic and Technology, 6, 98–102. https://doi.org/10.32620/aktt.2017.6.14
5. Fedorovych, O. Ye., Uruskyi, O. S., Lutai, L. M., Zapadnia, K. O. (2020). Optimization of the new technique creation life cycle in a competitive environment and stochastic behavior of high technology products market. Aerospace Technic and Technology, 6, 80–85. https://doi.org/10.32620/aktt.2020.6.09
6. Aleksiyev, O., Aleksiyev, V., Neronov, S. (2023). Multi-agents in transport process control. Bulletin of Kharkov National Automobile and Highway University, 100, 15–18. https://doi.org/10.30977/bul.2219-5548.2023.100.0.15
7. Kryvoruchko, O., Dmytriiev, I., Poyasnik, G., Shevchenko, I., Levchenko, Ia.; Dmytriiev, I., Levchenko, Ia. (Eds.) (2021). Transport and logistics services as a component of the transport complex and their quality management. Problems and prospects of development of the road transport complex: financing, management, innovation, quality, safety – integrated approach. Kharkiv: TECHNOLOGY CENTER, 42–62. http://doi.org/10.15587/978-617-7319-45-9.ch4
8. Levchenko, Ia., Dmytriiev, I., Dmytriieva, O., Shevchenko, I., Britchenko, I., Tripak, M. et al.; Dmytriiev, I., Levchenko, Ia. (Eds.) (2021). Problems and prospects of development of the road transport complex: financing, management, innovation, quality, safety – integrated approach. Kharkiv: TECHNOLOGY CENTER, 180. http://doi.org/10.15587/978-617-7319-45-9
9. Andriushchenko, K., Stefanyshyn, D., Sahaidak, M., Tepliuk, M., Buchynska, O., Rozmetova, E. et al. (2018). Process of resources provision management of the enterprise's activity with consideration of gender factor. Eastern-European Journal of Enterprise Technologies, 6 (3 (96)), 6–19. https://doi.org/10.15587/1729-4061.2018.150799
10. Simplifying the conditions for doing business during martial law: a detailed analysis of the draft law (2024). L&M Finance Group. Available at: https://lmfgr.com/tpost/i6a6z9lmp1-simplifying-the-conditions-for-doing-bus
11. Cherevko, N. (2024). Right to work under martial law: Legislative aspect in Ukraine. Ûridičnij Časopis Nacìonal'noï Akademìï Vnutrìšnìh Sprav, 14 (3), 55–65. https://doi.org/10.56215/naia-chasopis/3.2024.55
12. Samoilenko, Y., Britchenko, I., Levchenko, I., Lošonczi, P., Bilichenko, O., Bodnar, O. (2022). Economic Security of the Enterprise Within the Conditions of Digital Transformation. Economic Affairs, 67 (4), 619–629. https://doi.org/10.46852/0424-2513.4.2022.28