MODELLING OF FINANCIAL STABILITY IN LOGISTIC IN CONDITIONS OF UNCERTAINTY

Vitalijs Jurenoks, Vladimirs Jansons, Konstantins Didenko
Faculty of Engineering Economics
Riga Technical University
Kalku iela 1, Riga, LV1658, Latvia
E-mail: vitalijs.jurenoks@rtu.lv
vladjans@latnet.lv
ief@rtu.lv

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ABSTRACT
It is well known that random character may be an attribute inherent to the majority of economic events and processes, including also logistical processes. Modelling of logistical processes in conditions of uncertainty is complicated due to the lack of trustworthy information describing the conditions of uncertainty, and also in view of the random character of occurrences of deviations in the course of processes researched. Ignoring the evaluation of effect of certain factors during the research of processes occurring in transport logistics system (TLS) frequently expands “zone of risk”, entailing mistakes and discrepancies in the real time situation that, in turn, may finally result in significant material losses.

The principal objectives of this research work are:
- to consider the scheme of interaction of TLS participants regarding the process of cargo deliveries from the consignor to the consignee;
- to analyse the financial flows of TLS on the basis of a Latvian logistics firm;
- to consider an option of modelling the financial stability management of TLS participants in conditions of uncertainty;
- to model “zones of risk” of the financial performance of TLS participants in conditions of uncertainty.

THEORETICAL APPROACH TO THE PROBLEM
In logistical process a great number of participants are involved and linked in a unified TLS. At present in Latvia participants of logistical process are specialized logistics firms offering consignors and consignees a whole range of specialised services, such as:
- cargo forwarding in the port;
- handling customs clearance documentation;
- delivery of goods from the consignor to the nominated place of destination;
- dealing with transportation companies;
- tracing of cargoes that are being transported;
- other kinds of logistics services.

The scheme of interrelations of TLS subjects (participants) during cargo deliveries from the consignor to the consignee is presented in Figure 1.

![Image of the interrelationship scheme of TLS participants of cargo deliveries from the consignor to the consignee](image_url)

In logistical process three main types of flows may be identified, namely:
- transportation or materials flow (cargo flow movement in TLS from the consignor to the consignee);
- financial flow (movement of financial assets among TLS participants in accordance with contract obligations.

Figure 1: Interrelationship Scheme of TLS Participants of Cargo Deliveries from the Consignor to the Consignee
on delivery of cargoes from the consignor to the consignee; 
- information flow (information interchange among TLS participants).

Types of TLS flows in delivering cargoes from the consignor to the consignee are shown in Figure 2.

![Figure 2: Types of TLS Flows](image)

Financial relationship among TLS participants is stated at the stage of coordinating the delivery terms of cargoes from the consignor to the consignee and fixed in the cargo transportation contracts concluded. Close interaction of TLS participants pursuant to the contract signed should ensure appropriate flow of financial assets in TLS and strict adherence to the contract terms regarding delivery times and volumes set. However, as a rule, essential differences may occur between theory and practice in managing movement of TLS financial flows.

Taking as an example a Latvian logistics firm, we will analyse its financial flows with other TLS participants. In TLS two basic variants of organizing financial flows are possible, namely:

1. The logistics firm undertakes the responsibility of delivering cargoes directly from the consignor to the consignee. In this case the logistics firm receives from the consignor (or the consignee depending on the terms set in the contract) financial assets in full amount approved by the contract and required for transportation of the cargo from the consignor to the consignee. Besides that, the logistics firm is responsible for mutual settlement of accounts with other TLS participants.

2. The logistics firm accepts the responsibility for performing only part of operations in the logistics chain system. In this case the logistics firm receives from the consignor (or the consignee depending on the terms set in the contract) only a part of the financial assets approved by the contract and required for performing the TLS operations mentioned above. In this case relationships among TLS participants are fixed by a number of contracts concluded between separate TLS participants.

The scheme of financial flows among subjects of TLS is presented in Figure 3.

![Figure 3: Financial Flows of TLS Participants](image)

where $S_{1,i}$ - the planned amount of receipts on the account of logistics firm (LF) from the $i$-th consignor of cargo for the services to be rendered in TLS (modelled in accordance with contract terms using nonparametric methods), in euros; 
$T_{1,i}$ - the planned term of receipt of payment in the amount of $S_{1,i}$ from the $i$-th consignor of cargo on the account of logistics firm (LF) for the cargo registration and transportation services from the port of dispatch to the port of destination; 
$S_{2,i}$ - the modelled actual amount of receipts on the account of logistics firm (LF) from the $i$-th consignor of cargo for the services to be rendered in TLS (modelled on the basis of historical information using nonparametric methods), in euros; 
$T_{2,i}$ - the modelled actual term of receipt of payment in the amount of $S_{2,i}$ on the account of LF from the $i$-th consignor for the cargo registration and transportation services from the port of dispatch to the port of destination (modelled on the basis of historical information using nonparametric methods); 
$S_{3,j}$ - the planned amount of payment to be debited from the account of LF to the $j$-th participant of TLS for the cargo registration and transportation services to be rendered from the port of dispatch to the port of destination (modelled in accordance with contract terms), in euros; 
$T_{3,j}$ - the planned term of payment of the account in the amount of $S_{3,j}$ by LF to the $j$-th participant of TLS (modelled in accordance with contract terms); 
$S_{4,j}$ - the modelled actual amount of payment to be debited from the account of LF to the $j$-th participant of TLS for the cargo registration and transportation services to be rendered from the port of dispatch to the port of destination (modelled on the basis of historical information), in euros; 
$T_{4,j}$ – the modelled actual term of payment of the account in the amount of $S_{4,j}$ by LF to the $j$-th participant of TLS (modelled on the basis of historical information).

During the implementation stage of both the first and the second variant of interaction among TSL participants, the problems may arise concerning timeliness and completeness of settling accounts among the TSL participants, namely:
- there is a time gap between the terms of presenting the
accounts to be paid for the services rendered by
participants of TLS and real dates of receipt of payment
on the accounts of TLS participants for the services
rendered. Frequently the differences between the date of
presenting the account for the TLS services and the term
of receipt of payment on the accounts may take up to 2,
3 and in some cases even 6 and more months;
- there are “zones of risk” in which some of the TSL
participants may lose their financial stability;
- the necessity to use additional financial assets
(reserves) for stabilization of TLS activities becomes
evident.

METHODOLOGY AND ALGORITHM OF
SOLVING OF THE PROBLEM

Uncertainty in TLS is understood as a situation when
there is incomplete or no information at all about the
possible conditions of the system itself and the
environment in which the system functions. Conditions
of uncertainty are understood as various fluctuations of
factors of external and internal TLS environment, such as:
- changes in TLS infrastructure;
- fluctuating consumer demand for the services
rendered by TLS participants;
- fluctuating external and internal factors of TLS
environment.

Steady position of TLS activities is understood as the
ability of all TLS participants to perform a complete set
of functions and also maintain (or even increase) the
services to be rendered for a long period of time in the
conditions of uncertainty.

By financial stability we understand the ability of all
TLS participants to perform all the financial obligations
undertaken with the view of ensuring complete
continuous technological process in the terms agreed.

In the case of the logistics firm (LF) mentioned above
the conditions of uncertainty are as follows:
a) time delays between scheduled (planned) and actual
dates of receipt of payments on the account of logistics
firm;
b) amount of the necessary financial reserves of TLS
participant (in this case LF) required for maintaining its
financial stability at the moment of time \( t \).

The scheme of using the LF financial reserves is
presented in Figure 4.

For modelling the financial stability of LF the following
variables are used:
- \( \omega_i \) - the period of time in days between actual
(modelled) term of receipt of payment on the account of
firm \( T_2 \) from the \( i \)-th consignor (consignee) of the
cargo and planned (in accordance with the contract
terms signed) term of receipt of payment on the account
of LF for the cargo transportation and registration
services from the point of dispatch to the point of
destination \( T_1 \);
- \( \omega_{ij} \) - the period of time in days between the
modelled term of payment by the LF the account to the
\( j \)-th participant of TLS and planned (in accordance with
the contract terms signed) term of payment to the j-th participant of TLS for the services rendered. The variables for the case considered above are as follows:

\[ \omega_{21,j} = T_{2,j} - T_{1,j} \]
\[ \omega_{43,j} = T_{4,j} - T_{3,j} \]  \hspace{1cm} (1)

\[ \omega_{21,j} = T_{1} + \Delta_{21} \cdot R A N D \]
\[ \omega_{43,j} = T_{3} + \Delta_{43} \cdot R A N D \]  \hspace{1cm} (2)

where values of \( T_{1}, T_{3}, \Delta_{21}, \Delta_{43} \) are set proceeding from the average values received from processing historical information;

RAND is a random variable uniform distributed on the interval \([0, 1]\).

The initial information used in the process of modelling is presented in Table 1.

### Table 1: Initial Information used in Modelling

<table>
<thead>
<tr>
<th>NN</th>
<th>T1</th>
<th>S1</th>
<th>T2</th>
<th>w1</th>
<th>T3</th>
<th>T4</th>
<th>w2</th>
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<th>S3</th>
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<td>12/28/06</td>
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<td>0.3704</td>
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</tr>
</tbody>
</table>

Results of modelling the parameters of financial stability of the logistics firm are presented in Table 2.

### Table 2: Results of Modelling of Parameters of Financial Stability of Logistics Firm

<table>
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<tr>
<th>Date 2006</th>
<th>S1.t</th>
<th>S2.t</th>
<th>S3.t</th>
<th>S4.t</th>
<th>R(-)t</th>
<th>R(+).t</th>
<th>S.R.</th>
<th>S.t</th>
<th>Res.t</th>
<th>Total</th>
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<td>0</td>
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<td>0</td>
<td>0</td>
<td>10000</td>
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<tr>
<td>1/2/06</td>
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<td>0</td>
<td>2100</td>
<td>2100</td>
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<td>-2100</td>
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<td>2100</td>
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<td>0</td>
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<td>0</td>
<td>7900</td>
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<tr>
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<td>12/31/06</td>
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<td>17645</td>
<td>11200</td>
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<td>6445</td>
<td>407634</td>
<td>10000</td>
<td>417634</td>
</tr>
</tbody>
</table>

For each of \( S_i \), a histogram \( H_i \) is made with the help of which the behaviour of \( S_i \) is modelled:

\[ S_i = S(\omega_{1,i}, \omega_{2,i}, S_{1,i}, ..., S_{4,i}) \]  \hspace{1cm} (3)

The behaviour of \( R_i \) is simultaneously modelled:

\[ R_i = R(\omega_{1,i}, \omega_{2,i}, S_{1,i}, ..., S_{4,i}) \]  \hspace{1cm} (4)

The financial stability of logistics firm is represented as:

\[ Total_i \geq S_{4,i} \]  \hspace{1cm} (5)

where \( Total_i \) - the total amount of money resources on the analytical account (\( S_i \)) and in the reserve (\( R_i \)) at the moment of time \( t \).

\[ Total_i = S_i + R_i \]  \hspace{1cm} (6)
Results of modelling of financial stability of the logistics firm in every quarter of calendar year are presented in Table 3.

Table 3: Results of Modelling of Financial Stability of Logistics Firm in Different Quarters of Calendar Year

<table>
<thead>
<tr>
<th>Q1, Total</th>
<th>Q2, Total</th>
<th>Q3, Total</th>
<th>Q4, Total</th>
<th>S_4[t+1] + S_4[t]</th>
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<td>349257</td>
<td>12100</td>
<td>2100</td>
</tr>
</tbody>
</table>

The current state of balance of the LF at the moment of time \( t \) was modelled according to the algorithm 1A-4A:

\[ S_{i}^{R} = R(+)_{t} - R(-)_{t}; \quad S_{0}=0; \quad \text{Res}_{0}= R_{0}; \]

1A) \[ S_{i-1} + S_{i}^{R} \leq \text{Res}_{i-1} \quad \text{and} \]

\[ S_{i-1} + S_{i}^{R} < 0 ; \quad \Rightarrow S_{i} = 0 \]

2A) \[ S_{i-1} + S_{i}^{R} > \text{Res}_{i-1} \quad \text{and} \]

\[ S_{i-1} + S_{i}^{R} < 0 ; \quad \Rightarrow S_{i} = \text{Res}_{i-1} + S_{i-1} + S_{i}^{R} \]

3A) \[ S_{i-1} + S_{i}^{R} \geq R_{0} - \text{Res}_{i-1} ; \quad \Rightarrow S_{i} = S_{i-1} + S_{i}^{R} - (R_{0} - \text{Res}_{i-1}) \]

4A) \[ S_{i-1} + S_{i}^{R} \geq 0 \quad \text{and} \]

\[ S_{i-1} + S_{i}^{R} < 0 ; \quad \Rightarrow S_{i} = 0 \]

\( t = 1, 2, \ldots, 365. \)

The use of financial reserve \( R_{t} \) for maintaining the financial stability of logistics firm was modelled according to the algorithm 1B-4B (\( R_{t} = \text{Res}_{t} \)):

\[ S_{i-1} + S_{i}^{R} \leq \text{Res}_{i-1} \quad \text{and} \]

1B) \[ S_{i-1} + S_{i}^{R} < 0 ; \quad \Rightarrow \text{Res}_{i} = \text{Res}_{i-1} - S_{i}^{R} \]

2B) \[ S_{i-1} + S_{i}^{R} < 0 ; \quad \Rightarrow \text{Res}_{i} = 0 \]

3B) \[ S_{i-1} + S_{i}^{R} \geq 0 \quad \text{and} \]

\[ S_{i-1} + S_{i}^{R} \geq R_{0} - \text{Res}_{i-1} ; \quad \Rightarrow R_{i} = R_{0} \]

4B) \[ S_{i-1} + S_{i}^{R} < 0 ; \quad \Rightarrow \text{Res}_{i} = \text{Res}_{i-1} + S_{i-1} + S_{i}^{R} \]

\( t = 1, 2, \ldots, 365. \)

PRACTICAL USE OF STATISTICAL MODELLING

First time positiveness against the variables \( w_{1} \) and \( w_{2} \) are presented in Table 4.

Table 4: First time positiveness depending on \( w_{1} \) and \( w_{2} \)

<table>
<thead>
<tr>
<th>( w_{1} )</th>
<th>( f_{1}(w_{1}) )</th>
<th>( w_{2} )</th>
<th>( f_{2}(w_{2}) )</th>
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</thead>
<tbody>
<tr>
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<td>1</td>
<td>2</td>
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</table>

The graphic illustration of the first time positiveness is presented in Figure 6.

Figure 6: Scheme of First Time of Positiveness

The following parameters are shown in Figure 6:
- first time of positiveness;
- "zone of risk" of the financial stability of logistics firm.

The results of modelling allow identifying "zones of risk" of the financial stability of any TLS participant.
The results of modelling of first time of positiveness for two time delays $w_1$ and $w_2$ are shown in Figure 7.

The dependence of $w_2$ against Reserve is shown in Figure 8.

**CONCLUSION**

The use of the imitation modelling allows:
1) to model the behaviour of financial flows in TLS;
2) to model “risk zones” in which the financial stability of TLS participants has been distorted;
3) to identify the amount of the financial reserves required for TLS stability in “risk zones” of TLS participants;
4) to ensure financial stability of TLS participants in conditions of uncertainty;
5) to reduce the effect of external and internal environment factors on TLS behaviour and financial stability in the logistical process;
6) to enhance the performance efficiency and competitiveness of TLS participants.

**REFERENCES**


**AUTHORS BIOGRAPHIES**

VITALIJS JURENOKS was born in Riga, Latvia. In 1976 he graduated from the Faculty of Engineering Economics of Riga Technical University, and for ten years, has worked in an industrial enterprise in Riga. Since 1986, he has been lecturing at Riga Technical University, and in 1987 was awarded the doctoral degree in the science of economics (Dr.oec.). The main field of research pursued is planning, simulation and optimization of economic processes and systems. E-mail: vitalijs.jurenoks@rtu.lv.

VLADIMIRS JANSONS was born in Daugavpils, Latvia and is a graduate of the University of Latvia, where he studied mathematical science and obtained his degree in 1970. For eight years he has worked in the Computing Centre of the University of Latvia. Since 1978 he has been lecturing at Riga Technical University, where in 1983 he was awarded the doctoral degree in the mathematical science. The main field of research pursued is simulation and optimization of economic systems. E-mail: vladjans@latnet.lv.

KONSTANTINS DIDENKO was born in Jelgava, Latvia. In 1969 he graduated from the Faculty of Engineering Economics of Riga Technical University. Since 1969 he has been lecturing at Riga Technical University where in 1985 he obtained the doctoral degree in the science of economics. In 2006 he was elected a corresponding member of the Latvian Academy of Sciences. The main field of research pursued is planning and optimization of economic processes and systems. E-mail: ief@rtu.lv.