MODELLING OF FINANCIAL STABILITY IN LOGISTIC IN CONDITIONS OF UNCERTAINTY

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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.

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

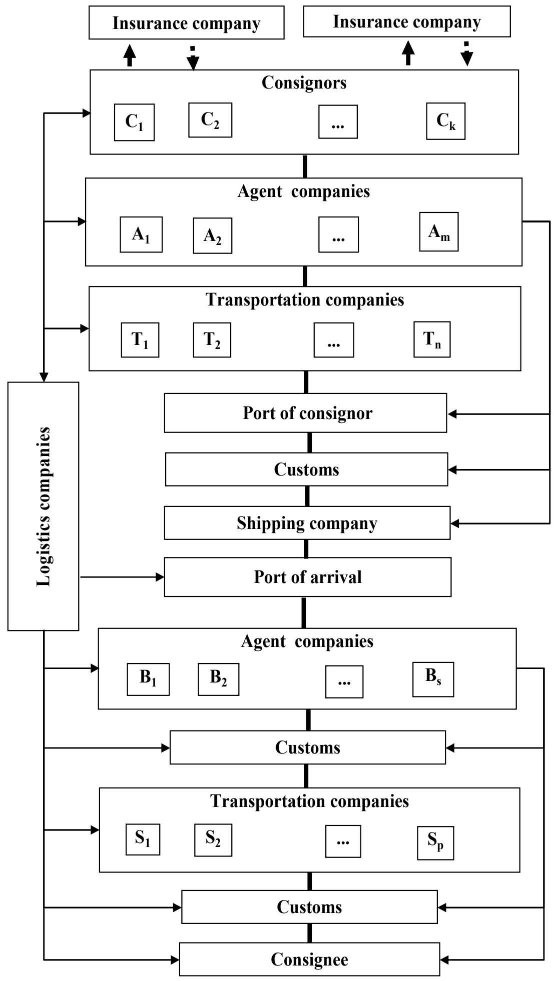

Figure 1: Interrelationship Scheme of TLS Participants of Cargo Deliveries from the Consignor to the Consignee

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

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.

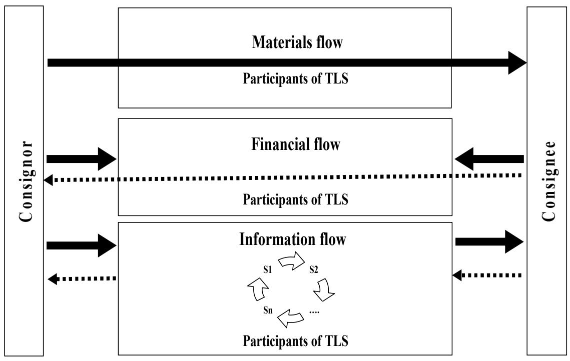

Figure 2: Types of TLS Flows

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.

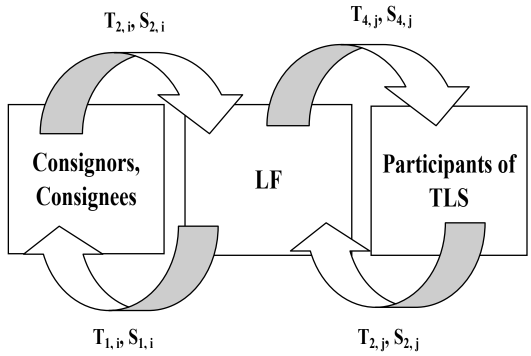

Figure 3: Financial Flows of TLS Participants

where $\mathbf{S_{1,i}}$ - 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;

$\mathbf{T_{1,i}}$ - the planned term of receipt of payment in the amount of $\mathbf{S_1}$ 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;

$\mathbf{S_{2,i}}$ - 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;

$\mathbf{T_{2,i}}$ - the modelled actual term of receipt of payment in the amount of $\mathbf{S_2}$ 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);

$\mathbf{S_{3,j}}$ – 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;

$\mathbf{T_{3,j}}$ – the planned term of payment of the account in the amount of $\mathbf{S_{3,,j}}$ by LF to the **j-**th participant of TLS (modelled in accordance with contract terms);

$\mathbf{S_{4,j}}$ - 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;

$\mathbf{T_{4,j}}$ – the modelled actual term of payment of the account in the amount of $\mathbf{S_{4,j}}$ by the 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.

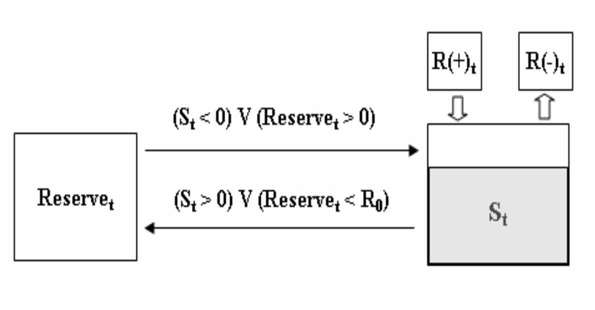

Figure 4: Use of Financial Reserves of Logistics Firm

$\mathbf{S_t}$ – balance of LF with TLS participants at the moment of time **t**, in euros;

$\mathbf{R\ (+)_t}$ – receipts to the account of LF from the consignor's (consignee's) account at the moment of time **t,** in euros;

$\mathbf{R\ (-)_t}$ - actual amount of payment to be debited from the account of LF to the other TLS participants at the moment of time **t**, in euros;

$\mathbf{Reserve_t}$ - current state of financial reserves of LF at the moment of time **t**, in euros;

$\mathbf{R_0}$ - initial (modelled) amount of financial reserves of LF, in euros.

On the basis of the information available it is possible to consider:

a) modelling of financial stability of TLS in conditions of uncertainty;

b) identification of "zones of risk " in management of financial stability of TLS in conditions of uncertainty by Monte- Carlo method. Process of modelling of LF financial stability is presented in Figure 5.

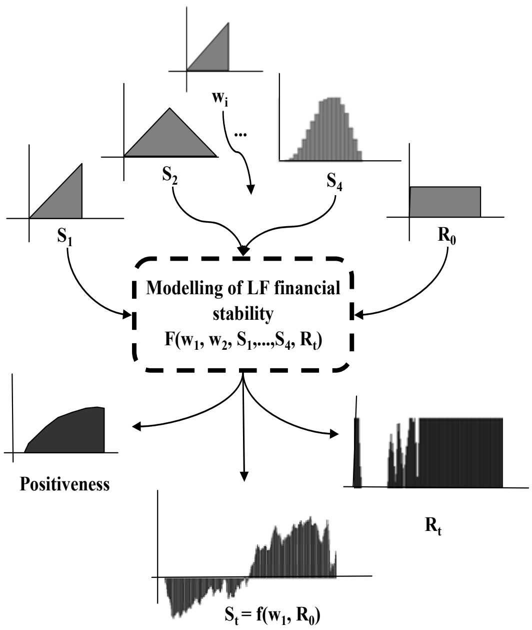

Figure 5: Process of Modelling of Financial Stability

For modelling the financial stability of LF the following variables are used:

- ω_{1i} - the period of time in days between actual (modelled) term of receipt of payment on the account of firm ($\mathbf{T_2}$) 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 ($\mathbf{T_1}$);
- ω_{2j} - 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:

$$\omega_{21,t} = T_{2,t} - T_{1,t}, \quad \omega_{43,t} = T_{4,t} - T_{3,t}, \tag{1}$$

$$\omega_{21,t} = T_1 + \Delta_{21} \cdot RAND, \quad \omega_{43,t} = T_3 + \Delta_{43} \cdot RAND, \tag{2}$$

where values of T_1, T_3, Δ_{21}, Δ_{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

NN	T_1	S_1	T_2	w_1	T_3	T_4	w_2	RAND()	S_3
1	1/5/06	2310	01/26/06	21	1/5/06	1/25/06	20	0.4090	2100
2	1/5/06	2310	01/22/06	17	1/5/06	1/18/06	13	0.6217	2100
3	1/5/06	2310	01/27/06	22	1/5/06	1/23/06	18	0.1511	0
4	1/5/06	2290	01/20/06	15	1/5/06	1/22/06	17	0.8813	2450
5	1/5/06	1800	01/18/06	13	1/5/06	1/19/06	14	0.3223	2100
6	1/5/06	2310	01/23/06	18	1/5/06	1/23/06	18	0.7412	2450
7	1/5/06	2310	02/05/06	31	1/5/06	1/26/06	21	0.6762	2450
...									
831	12/18/06	2470	12/28/06	11	12/18/06	1/8/07	21	0.5789	2100
832	12/18/06	2470	01/04/07	11	12/18/06	1/1/07	14	0.3984	2100
833	12/18/06	2470	12/27/06	20	12/18/06	12/28/06	10	0.3704	2100

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

Date 2006	$S_{1,t}$	$S_{2,t}$	$S_{3,t}$	$S_{4,t}$	$R(-)_t$	$R(+)_t$	S^R_t	S_t	Res_t	Total
1/1/06	0	0	0	0	0	0	0	0	10000	10000
1/2/06	0	0	2100	2100	2100	0	-2100	0	7900	7900
1/3/06	34495	0	0	0	0	0	0	0	7900	7900
1/4/06	0	0	2450	2450	2450	0	-2450	0	5450	5450
1/5/06	0	0	2100	2100	2100	0	-2100	0	3350	3350
1/6/06	0	9220	4900	4900	4900	9220	4320	0	7670	7670
1/7/06	11650	20280	0	0	0	20280	20280	17950	10000	27950
...										
12/29/06	14953	23180	15750	16100	16100	23180	7430	378636	10000	388636
12/30/06	6260	40053	17500	14000	14000	40053	22553	401189	10000	411189
12/31/06	2536	17645	11200	8750	8750	17645	6445	407634	10000	417634

For each of S_i a histogram H_i is made with the help of which the behaviour of S_t is modelled:

$$S_t = S(\omega_{1,t}, \omega_{2,t}, S_{1,t}, ..., S_{4,t}) \tag{3}$$

The behaviour of R_t is simultaneously modelled:

$$R_t = R(\omega_{1,t}, \omega_{2,t}, S_{1,t}, ..., S_{4,t}). \tag{4}$$

The financial stability of logistics firm is represented as:

$$Total_t \geq S_{4jt}, \tag{5}$$

where $Total_t$ - the total amount of money resources on the analytical account (S_t) and in the reserve (R_t) at the moment of time **t**.

$$Total_t = S_t + R_t. \tag{6}$$

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

Q1, Total	Q2, Total	Q3, Total	Q4, Total	$S_t + R_t + S2_{t+1}$	$S4_{t+1}$
10000	68020	221951	300565	10000	0
10000	61720	214951	298465	10000	0
10000	61735	217501	292165	10000	0
10000	71595	217491	290435	10000	0
10000	83920	224650	313555	10000	0
10000	81820	224650	343927	10000	0
10000	74470	224300	349257	12100	2100

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

$S^R_t = R(+)_t - R(-)_t$; $S_0 := 0$; $Res_0 := R_0$;

1A) $$\left|S_{t-1}+S_t^R\right| \le \mathrm{Re}\,s_{t-1} \ and \quad S_{t-1}+S_t^R<0 \quad ; \quad \Rightarrow S_t = 0$$

2A) $$\left|S_{t-1}+S_t^R\right| > \mathrm{Re}\,s_{t-1} \ and \quad S_{t-1}+S_t^R<0 \quad ; \quad \Rightarrow S_t = \mathrm{Re}\,s_{t-1}+S_{t-1}+S_t^R$$

3A) $$S_{t-1}+S_t^R \ge 0 \ and \quad S_{t-1}+S_t^R \ge R_0-\mathrm{Re}\,s_{t-1} \quad ; \quad \Rightarrow S_t = S_{t-1}+S_t^R-(R_0-\mathrm{Re}\,s_{t-1})$$

4A) $$S_{t-1}+S_t^R \ge 0 \ and \quad S_{t-1}+S_t^R < R_0-\mathrm{Re}\,s_{t-1} \ . \quad \Rightarrow S_t = 0$$

t =1, 2, … ,365.

The use of financial reserve R_t for maintaining the financial stability of logistics firm was modelled according to the algorithm 1B-4B ($R_t = Res_t$):

1B) $$\left|S_{t-1}+S_t^R\right| \le \mathrm{Re}\,s_{t-1} \ and \quad S_{t-1}+S_t^R<0 \quad ; \quad \Rightarrow \mathrm{Re}\,s_t = \mathrm{Re}\,s_{t-1}-\left|S_{t-1}+S_t^R\right|$$

2B) $$\left|S_{t-1}+S_t^R\right| > \mathrm{Re}\,s_{t-1} \ and \quad S_{t-1}+S_t^R<0 \quad ; \quad \Rightarrow \mathrm{Re}\,s_t = 0$$

3B) $$S_{t-1}+S_t^R \ge 0 \ and \quad S_{t-1}+S_t^R \ge R_0-\mathrm{Re}\,s_{t-1} \quad \Rightarrow R_t = R_0$$

4B) $$S_{t-1}+S_t^R \ge 0 \ and \quad S_{t-1}+S_t^R < R_0-\mathrm{Re}\,s_{t-1} \quad \Rightarrow \mathrm{Re}\,s_t = \mathrm{Re}\,s_{t-1}+S_{t-1}+S_t^R$$

t =1, 2, …, 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

w_1	$f_1(w_1)$	w_2	$f_2(w_2)$
1	0	1	0
2	0	2	52
3	0	3	73
4	0	4	58
5	0	5	66
6	4	6	64
7	0	7	44

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

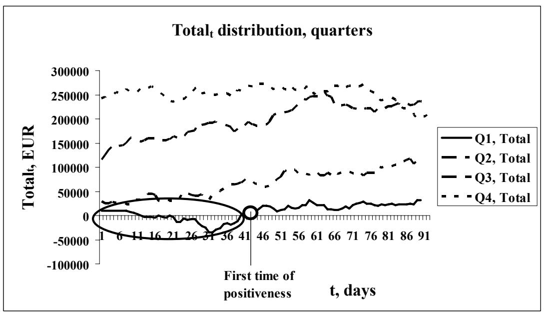

Figure 6: Scheme of First Time of Positiveness

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.

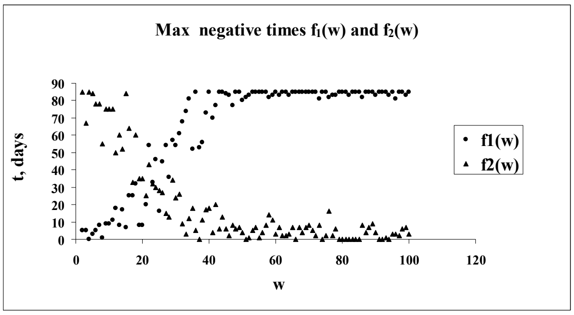

Figure 7: Results of Modelling of First Time of Positiveness for Two Time Delays w_1 and w_2

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

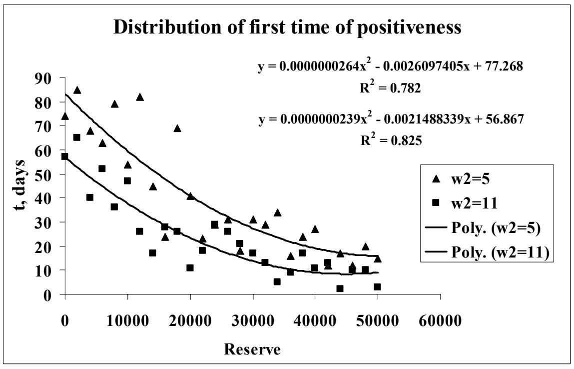

Figure 8. Distribution of First Time of Positiveness

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.

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