Influencing Financial Flows on Logistics Technology Solutions (Case Study on Transportation Mode Selection)

Summary: The attention to effective logistics system and material flow promotion has been increased in up-today economic transformation in Ukraine. Meanwhile, core process of any firm or system functioning still have place. The profit motive and high level of services for consumers’ purposes miss risk of capital erosion due to delaying of payments. Lack of financial flows make difficult of making any action, especially supporting high level of logistics servicing. Existing scientific and methods to the logistics management consider individually financial and material flows separately. The interaction of them needs further exploring. A frequency and transportation volume of logistic chain is unevenness and depends on seasonal consumption. Authors simulate the transportation service numerous different logistics chains with compatible cargos. Schedule of vehicles analysis per months and years shows irregularities of vehicles use in different systems. Orders redistribution between vehicles, led to synergetic effect that demonstrated by vehicles’ quantity decrease. Authors modelling and simulate the transportation service mode for manufacture of building material. Estimating the total cost for using auto and rail transport. Wilson models, just-in-time models for stock management have been used. Result of using auto transport instead of rail a been reduce of costs for more than 20%. Releases operating capital can effectively use in the logistics system operation cycle. Also, such actions provide acceleration of costs movement. The paper formalized relationship models of material and financial flows interaction. The proposed approach will allow evaluating the efficiency of various modes of transport, as well as improving the efficiency of the logistics system.

Key words: financial, flow, material, revenue, income, modeling, rail, auto

1. INTRODUCTION

Current global crisis has affected firms’ behavior on markets, forcing them to seek rational ways using their own assets. In 2013 Ukrainian market experienced lack of operating capital missing which led to the debt creation. Long-term investments, projects and products and services demand decrease led to absence of funds in the short term period. This affected delays in payments for goods, services, materials, according to the contracts, inevitably led to fines and aggravation of the company’s situation on the market (ShumIlo, 2014).

From the other side, crisis influenced on cargo transportation volumes decrease, forced to search for effective solutions of transportation problems associated with the goods...
delivery. The mode transportation service selection is still being important. There is a strong competition between railway and road transport in Europe (Janic, 2007). However, one should take into account various factors impact that can change in time (volume, distance, time, type of cargo, etc.). Poor decision-making methods have negative impact on the logistics systems efficiency and increase goods full delivery costs. Logistics models and methods are contributed to the material flow (MF) promotion decisions and transportation service (TS) mode selection. According to the State Statistics Committee of Ukraine overall transportation cargo volumes in 2012 by rail and road transport was about 71% (about 59% by road transport, almost 14,5% by rail) on the amount of traffic all modes of transport, including pipeline (State Statistics Committee of Ukraine, 2013).

The purpose of article is to find rational technology of transportation services ensures effective financial flow management.

Thus, this research analyses transportation service mode selection influence on financial flows in logistics chain.

2. REFERENCES ANALYSIS

The basis of the MF management process is information processing (technological, technical, economic, etc.) aggregate information about the functioning of the various objects that can be captured, transferred, convert and used to control functions such as planning, accounting, analysis, management and others (Starostka-Patyk & Nitkiewicz, 2014). Solving various logistical problems of MF management is important to systematically evaluate the results (information) throughout the supply chain. Information and MF are connected at the enterprise through supply, production and distribution links (Litomin, Tolmachov & Galkin, 2016).

The review references show problems that can be solved in the process of material management: carrier selection (Murphy, Daley & Hall, 1997), choice of transportation mode (Ambroziak & Tkaczyk, 2015), urban logistics (Comi, Delle Site, Filippi & Nuzzolo, 2012), the material flows distribution and restocking (Nuzzolo, Crisalli and Comi, 2012), the optimal order quantity (Wilson, 1943), use of distribution center (Gajewska & Filina-Dawidowicz, 2015), the own or hired transport and storage choice (Rushton, Oxley and Croucher, 2000), inventory placement in stock (Filina-Dawidowicz, & Postan, 2012), the choice of stores number (Belovodskya, 2011), enterprise resource planning (Monk and Wagner, 2006), order allocation tasks (Kannan, Khodaverdi, Olfat, Jafarian & Diabat, 2013) and supplier selections (Chen, 2011) and other (Anand, Quak, van Duin & Tavasszy, 2012) (Almeder C., Preusser, Hartl, 2009). For each of the problems considered different authors proposed different solution methods. However, the references analysis showed that each of the considered problems are solved separately. The obtained results obtained are individual decisions which do not give a comprehensive and system approach to the management of specific material flow (MF) and its financial flow.

The existence of large layoffs and taxation led to low consumption and hence to low demand creating a repeating circle with critical side effects in many countries of the world. The consumption was dramatically decreased, every form of trade was downscaled and
production was downsized to a desperate degree and, inevitably, shipping and export were seriously damaged (Folinas & Aidonis, 2012).

Assets used in the manufacturing process for one operating cycle, completely transfer their value to the cost of production and often change their original shape. Assets with cash, not directly involved in the production process (Lasher, 2010). They serve the cycling capital and combine the processes of production and sales (Buchmann & Jung, 2009).

Prerequisite for the economic activity realization now is the availability of working capital. The essence of current assets is determined by their economic role, the need to ensure the reproduction process, including both the production process and the process of treatment. Operating capital is indicator of the company’s financial analysis and is equal to the difference between current assets and short-term payables. The structure of current assets includes resources; VAT on the purchased assets; accounts receivable; investments; cash and cash equivalents; other current assets.

Companies have problems with delayed receipt of funds for goods shipped, accumulation in stock of unsold finished goods, untimely and incomplete fulfillment of contractual obligations suppliers and through other circumstances that give rise to the need for additional funds. To cover this needs only own sources becomes almost impossible. Therefore, to use companies should use only own operating capital currently which only own operating capital currently economically impractical for companies as it reduces the possibility of the companies on their own funding costs and increases the company’s risk of financial instability. In this case, the company is forced to turn to borrowing and attracting financial resources in the form of short-term bank loans, commercial loans and accounts payable.

In principle, the operating capital needs can be separated into two parts: fixed part and fluctuating part. The fixed part is probably defined in amount as the minimum operating capital requirement for the year. The more permanent needs (fixed assets and the fixed element of working capital) should be financed from fairly permanent sources (e.g. equity and loan stocks); the fluctuating element should be financed from a short-term source (e.g. a bank overdraft), which can be drawn on and repaid easily and at short notice.

Most of the researchers found a positive impact of operating capital management decisions on profitability of organizations (Asghar Ali & Syed Atif Ali, 2012; Buchmann & Jung, 2009; Gill, Biger & Mathur, 2010). It directly affects the liquidity and profitability of the firm. The results showed impact of operating capital on profitability and supported the hypotheses. These policies aim at managing the current assets (generally cash and cash equivalents, inventories and debtors) and the short term financing, such that cash flows and returns are acceptable (Buchmann & Jung, 2009; Chance, 2012).

Different measurements allowed evaluating effectiveness of manufacturing, transportation companies, logistics system, supply chain and other. Generally the operating capital can be calculated as differences between current assets and current liabilities.

3. THE LOGISTICS CHAIN FUNCTIONING OBSERVING

The logistics chain requirements to inventory management system, on the one hand, could be stable on the other hand, it could provide flexibility of decisions. Transportation modes
and their vehicle’s variations affect the order volumes, work schedules, delivery time, stock storage, technology operations in the supply chain. The supply intervals and sizes may vary depending in a logistics chains during different periods.

The system approach was used in the functioning analysis of the Ltd "PJSC «Smegnik» Kharkiv. The logistics chain, consists of: a raw materials supplier, transport participant on the site input material flow – the manufacturing plant (PJSC «Smegnik» ), fig. 1.

![Fig. 1 - The logistics chain](image)

Material necessity have been calculated on the base of average daily production capacity of the manufacturing plant (100,000 units finished products). To ensure the production of such a large products number, the following components and their quantity are required bitumen.

All of the presented components except bitumen, imported from local suppliers. Bitumen supplier is PJSC "KremenjugNPZ" Kremenjug city. Currently manufacturing plant uses rail transportation mode (railway transportation) for the bitumen supply. Bitumen is transported in bulk. The plant operates around the clock, without stopping the production line. Therefore, the supply volume order should ensure continuous operation of the manufacturing plant. The supply volume order by rail transport is 180 tons (is 3 railcars for 60 t each). Order time execution – 3 days. Transportation distance – 620 km.

There are warehouses of raw materials and finished goods warehouse at the manufacturing plant. Bitumen is stored in four silos (capacity 50 t each) with a total area of 500 m2 and a height – 4 meters. In this case there is a certain unit load, as bitumen stored in bulk. Basic equipment for the warehouse – this conveyor on which the raw material moves from a warehouse directly to production. Cargo motion control is done by computer equipment. Information processing occurs in real time. At the manufacturing plant used inventory management system with fixed time order. expected daily consumption, term costs order, expected consumption during delivery, the maximum power consumption during order, warranty reserve, stock limits, the maximum desired stock, the term flow reserve to an extreme level are the main parameters of the inventory management system with a fixed order size (Filina-Davidowicz & Postan, 2016): Transportation is carried out every Monday and consumed within a week. This schedule allows for uninterrupted production of finished products. The total bitumen amount stored in the warehouse for months is 3525 tons. Figure 2 shows a graph of the raw materials (bitumen) storage stock manufacturing plant for month.
Fig. 2 - Graph save bitumen for a month in stock manufacturer in the supply of rail transport

Another option to transported MF is by lorry. In the current situation, the purchase is carried out sufficiently in bulk, which leads to an increase in inventories of raw materials at the warehouse. That’s "freeze" a significant amount of financial resources in stocks. Also, the order time of raw materials is relative long (3 days), which leads to an increase in the size of stocks "in a way". Road transport used in raw materials transportation can provide greater supply flexibility. So, this would reduce the costs and provide more efficient use of funds released. In an automobile transport, the raw materials transported packed in special containers (can), which adds to the order cost. Gross mass of one running races - 450 kg., volume order by a vehicle is 19.5 tons, figure 3.

Fig. 3 - Graph save bitumen for a month in stock manufacturer in the supply by automobile transport

As demonstrated from the figure 3, the ceiling stock fell from 75 to 12.5 t, is 6 times. This means that the decreased costs for the purchase and storage of raw materials. The total
amount of bitumen stored in the warehouse for months under these conditions will be 1545 tons that is the stocks number of raw halved therefore halve the storage costs.

Therefore, the logistics chain requirements and inventory management system, on the one hand, can set the preferred transportation options. On the other hand, changes in the transportation mode can affect the order volumes, work schedules, delivery time, stock storage, technology operations in the supply chain etc. The supply intervals and sizes may vary depending in a logistics chains during different periods. Interrelation vehicle’s parameters and LC functioning efficiency are shown at Fig. 4.

![Fig. 4 – Interrelation between transportation parameters and logistic chain functioning efficiency](image)

Thus, the change in mode of transport leads to a change in the scope of delivery, timing, number of shipments, which in turn affects the costs of the system - the financial flows. To understand which option is better use is necessary to calculate the costs in the two cases.

4. EFFICIENCY CALCULATION FOR DIFFERENT TRANSPORTATION MODES

4.1 MODEL DESCRIPTION

By the parameters inventory management system with a fixed size of the order include: estimated daily consumption term costs order, expected consumption at the time of delivery, maximum consumption at the time of delivery, warranty reserves, ceiling stock, preferred stock maximum term costs to the reserve ceiling.

4.2 MODEL ASSUMPTIONS

Revenue and volume of transportations remains unchanged. The possibility of sharing 2 modes of transport has been ignored. Delivery can be carried out by one transport type in the period. Fixed volume system order has been used but other systems can be used as well. This model excludes failures and possible delays in deliveries and damages.
4.3 MODELING FULL COST

Using economic methods the different transportation modes cost-effectiveness use for the supply chain can be calculated. Total costs in both supply variants can be found as:

\[ TC = C_{\text{hold}}^{MF} + C_{\text{ord}}^{MF} , \]

where \( C_{\text{ord}}^{MF} \) - Ordering costs, USD; \( C_{\text{hold}}^{MF} \) - Holding costs, USD.

Calculation of ordering costs:

\[ C_{\text{ord}}^{MF} = C_{tr}^{MF} + C_{\text{cc},i}^{MF} + C_{\text{pur}}^{ord} , \]

where:
\( C_{tr}^{MF} \) - Delivery cost, including typically cost of ordering, USD;
\( C_{\text{cc},i}^{MF} \) - cost on buying bitumen order, USD;
\( C_{\text{pur}}^{ord} \) - Order purchase costs, USD.

Rail: \( C_{\text{ord}}^{MF} = 980 + 225000.00 + 47660.42 = 273640.42 \) USD;
Auto: \( C_{\text{ord}}^{MF} = 1330 + 225000.00 + 2436904 = 228766.904 \) USD.

Delivery cost, including typically cost of ordering can find as:

\[ C_{tr}^{MF} = N_{i}^{ord} \cdot TSC_{i}^{t} + N_{i}^{ord} \cdot C_{i}^{ord} , \]

where:
\( TSC_{i}^{t} \) - Transportation service cost for \( i \)-th transportation mode in period \( t \), USD;
\( N_{i}^{ord} \) - Number of orders in period \( t \), units.

Rail: \( C_{\text{ord}}^{MF} = 4 \cdot 230 + 4 \cdot 15 = 980 \$ / month \);
Auto: \( C_{\text{ord}}^{MF} = 14 \cdot 80 + 14 \cdot 15 = 1330 \$ / month \);

The selection criterion of «alternative business», based on the desire for changing technology to spending less expenses to achieve more effective results (Galkin, 2015). This represents the cost of the project, estimated in terms of "lost or missed opportunities" to engage other available alternative activities that require the same time or the same resources. The alternative expense shows that this project among all others will show the maximum economic benefit when limited in money, time and other resources. Raising funds in the short term can be taken from the credit accounts, overdrafts or as a result of redistribution of costs. Thus it is necessary to take into account the cost of investment in a particular period. Costs connected with purchase should include alternative investments of using cost:

\[ C_{\text{pur}}^{ord} = N_{i}^{ord} \cdot Q_{\text{ord}} \cdot P \cdot (1 + d) \cdot q_{\text{nom}}^{MF} \cdot P , \]
where:

$Q_{ord}$ – Order quantity by Rail/Auto transport, ton;

$P$ – Purchase of one ton of raw materials including taxes, USD;

$q_{non}^{MF}$ - Mouth materials demand quantity, units / month;

$dx$ - Discount rate in period t (accept 4% per month).

Rail: $C^{ord}_{parc} = 5 \cdot 180 \cdot 300 \cdot (1 + 0,04)^{0,25} - 750 \cdot 300 = 47660,42$ USD;

Auto: $C^{ord}_{parc} = 14 \cdot 54 \cdot 300 \cdot (1 + 0,04)^{0,0715} - 750 \cdot 300 = 2436,904$ USD.

Part of the period can be calculated as on which investments took place:

$$t = \frac{\tau}{N_{ord} \cdot \tau},$$  \hspace{1cm} (10)

where:

$\tau$ - Working days number in the month of the company, days.

Rail: $t_{rail} = \frac{30}{4 \cdot 30} = 0,25$ ;

Auto: $t_{auto} = \frac{30}{14 \cdot 30} = 0,0715$ .

Thus, capital cost on buying bitumen:

$$C^{MF}_{sc,t} = P \cdot D \cdot (1 + dx)^{\prime},$$  \hspace{1cm} (11)

where:

$D$ - Demand quantity in period t, tons;

Auto or Rail: $C^{MF}_{sc,t} = 300 \cdot 750 = 225000,00$ (USD);

Calculation of holding costs:

$$C^{MF}_{hold} = C^{MF}_{bc,t} \cdot \sum_{i=1}^{\tau} Q_i \cdot t,$$  \hspace{1cm} (12)

where:

$C^{MF}_{bc,t}$ - Storage cost of 1 ton volume per day, USD·ton/day;

$Q_i$ - Holding volume per day in stock, tons;

$\tau$ - Days in this volume, days.

Rail: $C^{MF}_{cost} = 3525 \cdot 201,314 = 709631,85$ $/ month$ ;

Auto: $C^{MF}_{cost} = 1545 \cdot 172,111 = 265909,95$ $/ month$ .
Influencing financial flows on logistics technology solutions (Case study on transportation mode selection) 69

Storage cost of 1 ton volume per day:

\[ C_{hc,t}^{MF} = \frac{C_{\text{ins},t}^{MF} + C_{\text{wh},t}^{MF}}{\sum_{i} Q_i \cdot t}, \]  

(13)

where:

- \( C_{\text{wh},t}^{MF} \) - Cost for warehouse space, USD;
- \( C_{\text{ins},t}^{MF} \) - Insurance cost, USD.

Calculation of reserved stock costs includes alternative investments of using these costs in time period:

\[ C_{\text{ins},t}^{MF} = \sum_{i} Q_i \cdot t \cdot (1 + dx)^t \cdot I_{\text{ins}}, \]

(14)

where:

- \( I_{\text{ins}} \) - reserved stock cost per ton, USD/ton (0.5 USD).
- Rail: \( C_{\text{ins},t}^{MF} = 3525 \cdot (1 + 0.04)^{0.25} \cdot 0.5 = 1779,867 \) USD;
- Auto: \( C_{\text{ins},t}^{MF} = 1545 \cdot (1 + 0.04)^{0.0715} \cdot 0.5 = 774,666 \) USD.

Warehouse cost for storage, package and handling can found like:

\[ C_{hc,t}^{MF} = h_{wh} \cdot \sum_{i} Q_i \cdot t \cdot (1 + dx)^t, \]

(15)

where:

- \( h_{wh} \) - cost of warehouse functioning per ton, USD/ton (accept 10 USD);
- Rail: \( C_{hc,t}^{MF} = 3525 \cdot (1 + 0.04)^{0.25} \cdot 10 = 35597.33 \) USD;
- Auto: \( C_{hc,t}^{MF} = 1545 \cdot (1 + 0.04)^{0.0715} \cdot 10 = 15493.33 \) USD.

Results of estimation are presented in table 1.

### Table 1. The logistics chain calculation performance

<table>
<thead>
<tr>
<th>Operation performances</th>
<th>Rail</th>
<th>Auto</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity, tons</td>
<td>60</td>
<td>20</td>
</tr>
<tr>
<td>Capacity utilization coefficient</td>
<td>1</td>
<td>0.9</td>
</tr>
<tr>
<td>Transportation time, days</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Order quantity, tons</td>
<td>180</td>
<td>54</td>
</tr>
<tr>
<td>Maximum desirable stock, ton.</td>
<td>180</td>
<td>54</td>
</tr>
<tr>
<td>Mouth materials demand materials, ton.</td>
<td>750</td>
<td>750</td>
</tr>
<tr>
<td>Period expenditures of order, days</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>The limit stock level, days</td>
<td>3</td>
<td>0.5</td>
</tr>
</tbody>
</table>
Using relation (13) storage cost of 1 ton volume per day could be calculated:

\[ C_{hc_t}^{MF} = \frac{1779,867 + 35597,33}{30} = 1186,577 \text{ (USD/day)}; \]

\[ C_{hc_t}^{MF} = \frac{774,666 + 15493,33}{30} = 542,27 \text{ (USD/day)}. \]

Table analysis shows that cost per order and annual holding cost per unit in each variant depends on transportation mode. The economic order quantity is different too.

Comparing two variants we can find effect from transportation mode option:

\[ |TC_{rail}^{MF} - TC_{auto}^{MF}| = \Delta TC, \quad (16) \]

where:

\( \Delta TC \) - differences between two comparing options, which shows low cost gain, dollars. In this case the auto transportation variant is more prefer than rail on 66012,73 USD / month.

Basing on table 1 will show technology impact to main indicators of fig. 8-11.

Analysis of Figure 8 indicates that total bitumen stored in a warehouse during the month redact twice, from 37377,197 USD to 16237,99 USD. Order quantity reduced from 180 ton to 54 ton leads to reduce period expenditures of order to 2 days, figure 9. It allows to decreased operating capital fluctuating part, spent on ordering, to 44873,52 USD. Figure 10 demonstrates that operating capital fixed part decreased on 6 times. It allows release 18750,00 USD additional funds. Total cost on distribution of MF per month decrease to 21,2%. Analysis of average cost on MF per day, fig. 11, shows reduction to 2200,42 USD/day.
5. DISCUSSIONS & CONCLUSIONS

Change of transportation mode leads to variation in the supply chain of raw materials and operating parameters of the effectiveness of different processes, as a result. The obtained results of transition from railway to road transport show a decrease turnaround time, reducing „stocks in way” and inventory stock to 2.3 times. The proposed design solutions have reduced the operating capital of the enterprise directed on maintenance of a stock level in 6 times. It allows release 18750,00 USD additional funds.
Systemic effects caused by the use of road transport instead of rail, influenced the technological component of the functioning of the logistics system. The decrease order quantity and increase their frequency, reducing storage volume which impact on cost (reduce them more than 20%). It gives opportunity to increase the operating capital of participants in the logistics system. Thus, the change in mode of transport (logistics component) leads to a change in financial flow.

Formalized relationship models of material and financial flows interaction by the example of the use of different modes of transport. The proposed approach will allow evaluating the efficiency of various modes of transport, as well as improving the efficiency of the logistics system as well.

References