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## TRANSPORT FLEET SIZING BY USING MAKE AND BUY DECISION-MAKING

**ABSTRACT:** *Cost reduction is among the main quoted reasons for logistics outsourcing, while transport capacities and operations are among the most outsourced logistics areas. However, according to transaction costs theory, there is often room for transport insourcing. Furthermore, nowadays many authors stress that mixed solutions can give better results than “make” or “buy” alternatives.*

*“Make or buy” decision-making normative models, methods, and procedures in transport planning are not much explored. Instead, research is rather focused on carrier selection techniques, whereby it is supposed that outsourcing transport capacities is the most suitable solution.*

*The purpose of this paper is to contribute to the body of literature on classical “make-or-buy” decision-making in transport fleet*

*sizing in a non-logistics enterprise. It goes beyond the basic “make or buy” decision-making, and intermediate solutions (i.e., “make and buy”) are explored. Practical directions are given according to theoretical principles, and a case study is used to exemplify the main deductions.*

*The research also has practical implications. Many enterprises in transition economies have faced the question of what to do with their in-house transport fleets. The obtained results are of interest to merchants and manufacturing enterprises that already have a private transport fleet and are considering how to rationalize it.*

**KEY WORDS:** *Transport Management, Fleet Sizing, Make and Buy Decision, Optimization, Transport Outsourcing, Privatization*

**JEL CLASSIFICATION:** C53, C61, D21, D29, L14, M29

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## **1. INTRODUCTION**

One of the most important tasks in logistic distribution systems design is modelling transport capacity size, and structure. In order to meet transport demands, transport managers can use their own transport fleet, carriers/logistics providers, or both of these resources. Having in-house transport services can render less transport costs per shipment and independence in the transport market. On the other hand, overcapacity of an in-house fleet is very expensive.

The preliminary focus is on the “make-or-buy” (MOB) decision-making procedure, as a managerial tool for in-house transport fleet sizing in a non-logistics enterprise, according to transport demand characteristics. As with most transport optimization problems, the objective is cost minimization within an accepted level of transport services in a given environment. However, while the fleet sizing literature is mainly concerned with the total fleet needed to meet transport demands, here we deal with an optimal sourcing concept. The paper goes beyond the classical “make or buy” decision-making to focus on intermediate solutions, i.e., “make and buy” - (MAB). The purpose of the paper is to contribute to the scarce body of literature which provides practical directions, rules, and methods for in-house fleet sizing in non-logistics enterprises – primarily manufacturers and merchandisers. Hence, the presented findings could be helpful to strategical and tactical transport and logistics planners.

During the process of privatization in Serbia road transport capacity and resources have been among the first areas to be completely outsourced in most non-logistics enterprises. Many firms then started to buy services from former employees. Here it is argued that total fleet externalization may be more a matter of company strategy, than an economic decision in a stable market. The case of a former state oil company will be used to exemplify the main ideas and research results. This example shows that, even in transition economies, there exists cases where total transport outsourcing may not be economically justified. The obtained results could inspire all merchant and manufacturing enterprises that already have a private transport fleet and are considering transport outsourcing.

The rest of paper is organized as follows. The second section of this paper is a brief review of the literature. In the third section practical directions are given, according to the theoretical foundation, to help strategic transport managers determine an optimal in-house transport fleet size and level of transport services outsourcing, according to time-demand characteristics. The analysis includes “make”, “buy”, and mixed solutions in cases with no capacity constraints. In the

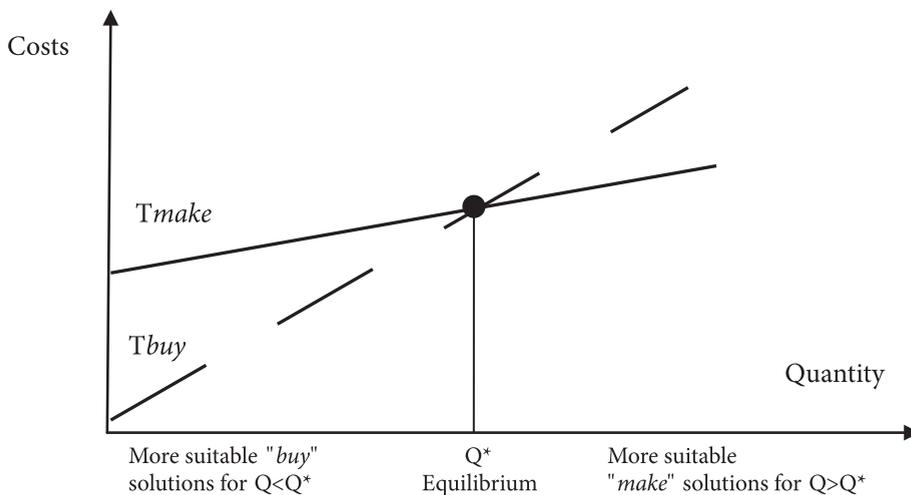
fourth section, a case study of a former Serbian oil merchant enterprise is briefly described. It is used to exemplify the presented MOAB method. The main results and discussion are given in the fifth section, while the research limitations, implications, and, finally, the conclusion, are in the last two sections, respectively.

**2. THEORETICAL BACKGROUND**

The body of literature concerned with normative models of MOB decision-making procedures in transport planning is scarce, and the more specific area of research into intermediate solutions (MAB) is neglected. The nature of the “make or/and buy” (MOAB) decision-making problem in transport will be briefly explored through background economic theory and the main methods and techniques of fleet sizing.

The roots of a “make or buy” decision are related to product purchasing. At its core there is a very simple logic. Comparing the costs of own production and vendor purchasing for a different number of units, there is an equilibrium  $Q^*$  between cost effective “make” and “buy” solutions (Figure 1). This very simple model is the essence of “make or buy” economic criteria for decision-making.

**Figure 1:** Basic economic “make or buy” decision-making model



Source: Männel (1976, p. 27)

In textbook discussions on the MOB problem, outsourcing is often justified on technological grounds. Suppliers may have better equipment, more capacity, or reach economies of scale (Arya et al., 2005). Some authors find that firms contract out business services to smooth production cycles, to benefit from specialization, or to realize labour cost savings (Abraham and Taylor, 1996). Although such a decision is mainly made on the ground of costs, there are some attempts in manufacturing to develop a multi-attribute make vs. buy decision-making process (e.g., see Platts et al., 2002).

Many theories are used in the literature to further explore the MOB problem. The list includes, but it is not limited to, transaction cost theory (TCT), network theory, agency theory, resource-based view theory, and total cost of ownership. The focus in our research will be on the first and the most used: transaction cost theory.

TCT was originally developed by Williamson (1975, 1985), and represents one of the most developed frameworks dealing with organizational boundaries. Basically, transaction cost economics aims to explain when an internal mode of organizing (i.e., hierarchy) will be preferred over an external mode of organizing (i.e., market) (Barthélémy and Quélin, 2000). This provides an appropriate conceptual framework for examining the efficiency of organizing a firm's transportation of finished goods in-house vs. out of house. TCT also considers behaviour and opportunism in market transactions. Transaction efficiency is influenced by asset specificity, uncertainty, and frequency. TCT suggests that a firm should internalize transactions if there exist three conditions: high asset specificity, high level of internal and external uncertainty, and high transaction frequency<sup>1</sup> (Williamson, 1985, Wilson 2001, Ellram and Billington, 2001 etc.).

There are few academic sources on transport purchasing processes (Holter et al., 2008). However TCT theory has already been used in developing some of the rare MOB decision-making models in transport (e.g., see Bienstock and Mentzer, 1999). Bienstock and Mentzer (1999) indicate that there may be important factors within the nature of the “supplying industry” (e.g., road transport industry) that impact the buyer's decision. On the other hand, the body of outsourcing literature usually points out that transportation costs are the most important reason for

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<sup>1</sup> According to Williamson (1985), internal uncertainty is behaviour uncertainty, i.e., related to the difficulties in forecasting the behaviour of the supplier, especially in term of opportunism. The relationship between internal uncertainty and transaction costs are one of the pillars of TCT. External uncertainty is related to market uncertainty and lack of knowledge about events in the environment. This type of uncertainty is multidimensional.

capacity outsourcing (e.g. see Laarhoven et al., 2000, Pedersen and Gray, 1998, etc.).

However, although TCT is the most common theory used to explain MOB decision-making, many authors point out its limitations. Transaction cost economics has almost always treated “the choice of organizational structure in either-or-terms” (Krzeminska and Mellewigt, 2006). Parmigiani (2003, p. 18) recognizes that TCE “cannot explain why firms would choose to use both sourcing modes”.

Porter (1980) first explicitly considers “make-and-buy” as an alternative to vertical integration and the make-or-buy perspective. He explains it primarily by means of optimal capacity utilization. Firms perform a “make-and-buy” strategy when their maximum production capacity is exceeded by demand and therefore has to be satisfied by market contracting. That usually means producing most units internally and buying only the residuum. It should be noted that his focus was on manufacturing. Moreover, it is hard to find the practical evidence to follow this general principle.

However, not many attempts to develop decision-making normative models have been made according to Porter’s research. There is a particular literature gap relating to the normative models and procedures used in transport and logistics services.

The basic MOB model can also be used as a frame for MOB decision-making in transport services. However, it has to be to some extent adapted according to transport service and sector characteristics. The important differences between transport (logistics) and manufacture outsourcing are discussed in Maltz and Ellram (1997). They notice that even the name “make or buy” indicates that the primary idea is related to manufacturing.

Economies of scale allow in-house fleets to be used efficiently and to cost less than external carrier(s). Topenčarević (1987, p. 232) uses the basic economic model (Fig. 1) to express the margin between the carrier’s cost and income, i.e., the point where a carrier starts to make profit thanks to economies of scale. However, time and even spatial demand characteristics during a medium-term horizon impact on transport fleet utilization more than total annual transport volume. Highly unpredictable daily demand, with non-stationary demand time series, result in low and inefficient utilization of an in-house fleet. In such a case it is better to contract carriers from the transport market.

In the literature on decision-making concerning private vs. hired carriers, the prior studies focus on the identification of factors that affect carrier selection decisions (Min, 1998). In contrast to the abundance of empirical studies, analytical modelling efforts are scarce (ibid). For example, one of most important limitations of the proposed decision support system (DSS) in the same paper is that only “make versus buy” solutions are considered, while the mixed solution (MAB) has been mostly ignored.

A wide range of operation research methods and techniques for capacity planning and/or fleet optimization can be found in the literature. Authors mostly use tools like integer linear and mixed programming, queuing, and probabilistic and heuristic methods, as well as simulation. Most of them are static and rather theoretical approaches with many limitations to their applicability in the real environment (e.g., see List et al., 2003 and Bertazzi et al. 1997). Also, many fleet sizing models and methods are still integrated with inventory models and are concerned with overall fleet sizing, necessary to meet all transport demands (e.g., see Morales, 2000).

Today simulation tools are widely used to solve fleet sizing problems (Lesyna 1999). However, the rare published research papers on transport capacity MOB simulation models usually have a common weakness. In-house vehicles are often treated as a specific carrier, which offers transport services within certain unit costs (e.g., in Bienstock and Mentzer, 1999). But the price of in-house service depends on economy of scale, because transport costs consist of fixed asset costs and variable operational costs. Time demand characteristics, as well as transport distances and load utilization, strongly affect vehicle utility and unit transport costs. Due to this limitation similar models, which are of strategic importance to the firms, usually can be implemented only at the operational level of management.

Kavussanos and Alizadeh-M (2001) explore this issue from the carriers' perspective. They investigate the relationship between freight rates and transport demand seasonal variations, and indicate that knowledge of these relations could help multi-vessel companies to diversify and extend their investments to vessels of different sizes, as well as to operate vessels under contract.

This paper focuses on an optimal MAB sourcing concept, i.e., the mixed solution. However, “make” and “buy” alternatives, as extreme solutions, are not excluded from the analysis of fleet planning and sizing. TCT and Porter's idea are used as the theoretical foundations for developing practical directions for an optimal in-house fleet sizing. We could not find many papers where the nature of time

demand is related to practical directions for MAB decision-making in transport planning. Some make and/or buy approaches in transport planning on strategic, tactical, and/or operational levels in enterprises are given in Cakić, 2002, Gajić et al., 2004, and Cakić, 2009.

### **3. MOAB DECISION-MAKING IN TRANSPORT FLEET SIZING**

According to the discussion in the previous section, it can be assumed that, if the enterprise has a relatively stable market position, there should be room for a well-utilized in-house fleet. It in turn gives economies of scale, which obtain less transport costs per unit than external carriers. However, it is still hard to define exactly the optimal sizes of in-house and external transportation fleets in a dynamic environment.

As mentioned, a body of literature about related models and methods which gives practical directions is scarce. As an effort to bridge this gap we propose a method for calculating an optimal fleet size within MOAB decision-making. The basic idea is to develop an optimal sourcing mix, whereby the in-house fleet reaches economies of scale and good utilization. A portion of “demand surplus” strongly depends on demand time characteristics. In this sense it follows the thinking of TCT, that hired carriers are dedicated to meet demands with high time variability, while an in-house fleet should be fully utilized. The main extension from Porter’s idea is that demand variability affects an optimal sourcing mix and, consequently, in-house fleet sizing. Also, the extreme solutions are included in the set of possible solutions, although the mixed solutions as a rule are expected in stationary systems. An optimal sourcing mix has to meet transport demands with a minimum of total transport costs, considering in-house and hired transport capacity characteristics and transport demand fluctuations.

Here it is supposed that a non-logistics (i.e., manufacturing or merchant) enterprise has an in-house transport fleet developed to meet all transport needs. This was the case with many companies both in developed and developing countries in the early 1980s. Then in the Western countries the transport market underwent liberalization and in the developing countries the process of economy transition and privatization began. This is a very suitable moment to consider the shaping of an optimal outsourcing mix. The experience in transition countries shows that economic transition and privatization are often triggers for transport rationalization and outsourcing in non-logistic enterprises (Rydzkowski and Spraggins, 1994, Rodnikov, 1994, van den Bloomen and Purvanov Petrov, 1994) and greater competition in the transport market (Božić and Aćimović, 2006).

Furthermore it is also supposed that transport demands are stochastic and stationary. This is the case when the market is relatively stable with seasonal fluctuations, and the enterprise is not considering substantial changes, such as entering into new or losing current markets.

In such conditions, the proposed method has to answer the question of which size in-house transport fleet minimizes overall transport costs.

The optimal fleet mix is defined by two additional conditions:

- Using own trucks is preferred to hired carriers in an operative (daily) planning period, but
- In-house trucks have to achieve at least a margin of profitability in the medium or long term, or transport units will be externalized.

The objective function is minimizing the long-run overall transportation costs by distribution of transport tasks between the in-house fleet and hired carriers, while keeping an acceptable level of service quality.

It is assumed that the transport system has no capacity constraints, i.e., both in-house and hired fleets are available with no limitations. Thus, the decision-making is focused on the selection of vehicles from both sources resulting in the best performance, e.g., on an optimal sourcing mix, which minimizes overall transport costs. It is dedicated to the higher management level, and does not deal with operational level problems such as dispatching, scheduling, loads consolidation, demand cancellation, etc.

To keep the focus on the main idea, we adopted some conditions and constraints in the further analysis, as follows:

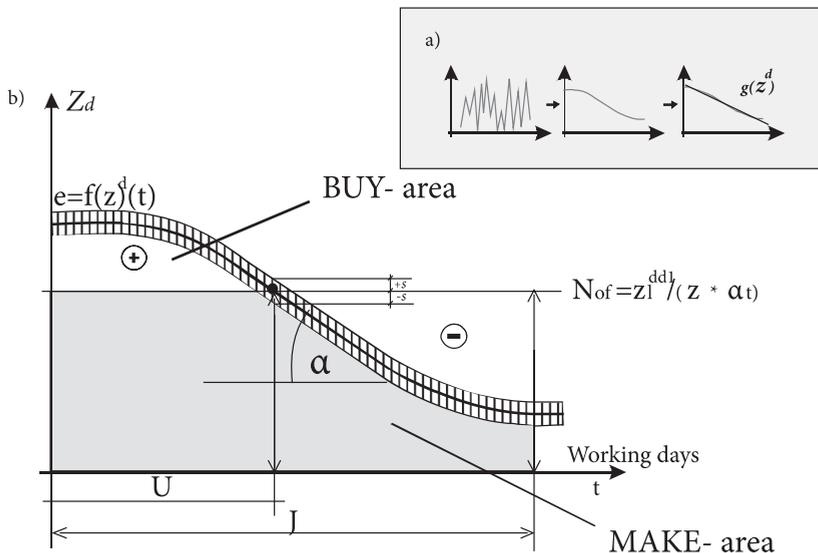
- The number of daily transport demand  $z^d(t)$  is a random, independent, stochastic, and stationary variable.
- Transport demands should be satisfied on the same day as they arrive.
- There are no limits regarding the number of total vehicles available to meet transport demands.
- A homogenous fleet, average transport distance, and shipment size are used in the calculation, as well as average in-house fixed and variable costs.
- All carriers use an average freight rate for the same (average) transport distance.

For the given conditions, within a relatively stable system and unchanging business situation, it is possible to forecast an annual transport demand time series with a forecast error  $\Delta z^d$  according to the history database on demand time series. Some empirical evidence confirms that, even in very unstable market conditions, a suitable demand forecast for in-house fleet sizing is possible, according to the history database (e.g., see Cakić, 2002). Furthermore, for more convenient visualization, it is suitable to reorder the stochastic demand time series and represent it as a non-increasing or non-decreasing order. This reordering has no effect on the share of in-house vehicles in the total transport volume.

The trend lines of such a reordered time series will always show better results in  $R$ -squared value and lower standard error of regression  $s$  than those related to the trend lines of the original time series (Cakić, 2002). The reordering can be applied on monthly series  $g_j(z^d(t))$  for month  $j$  (Figure 2a), or annual series  $e(z^d(t))$  (Figure 2b). The reordering process and adding of a trend line is shown in Figure 2a. The empirical average interval of variation  $\Delta z^d$  (forecast error) depends on fixed periods and their lengths (month, year). The principal transport tasks distribution between in-house and hired carriers is given in Figure 2b.

**Figure 2:** Daily transport demands in an observed period (month, year);

- a) Demands reordering from stochastic to non-increasing time series,
- b) Principal “make” and “buy” demand distribution during the time horizon



Source: Cakić (2002)

Based on the definition that Talley (2001) used for a “time-series statistical cost-function” for cost processing, we can say that here we deal with a “modified time-series statistical demand-function”.

The annual transport demands, as presented in Figure 2b, can be distributed between own fleet and hired vehicles, according to planned annual transport volume, above transport demand characteristics, and the main in-house transport fleet performance. The maximum daily transport demand that can be satisfied by own fleet  $Z_1^d$  depends on an average shipment size  $q$ , a rate of technical ability<sup>2</sup>  $\alpha_t$  and  $N^{of}$  (Fig. 2a):

$$Z_1^d = N^{of} \times \alpha_t \times z^{d1} \tag{1}$$

The average number of daily deliveries per vehicle  $z^{d1}$  depends on the existing time for loading or unloading, average traffic speed, distance, etc. This parameter may be treated as the same for both in-house and hired vehicles, because the factors influencing delivery lead-time do not impact on “make or buy” decision-making if all vehicles are treated equally at the terminals.

Transport demands in the forecast period (one year), which can be satisfied by the in-house fleet, consisting of  $N^{of}$  homogenous vehicles, can be calculated as follows:

$$Z^{of} = \begin{cases} z_1^{of} = z_1^d * U, & z^d(t) \geq z_1^d \\ z_2^{of} = \int_{t=U+1}^J e(z^d(t))dt & z^d(t) < z_1^d \end{cases} \tag{2}$$

$U$  – the number of workdays when  $z^d(t) > z_1^d$  in the planning year.

Total number of transport demands that can be satisfied by own truck fleet annually is:

$$Z^{ofy} = Z_1^{of} + Z_2^{of} \tag{3}$$

The remaining annual transport demands that must be satisfied by hired carriers are:

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<sup>2</sup> An average technical ability is a parameter related to the daily average number of in-house trucks which are not being repaired or maintained and can be promptly used to meet transport demands.

$$Z^{hcy} = Z^y - Z^{ofy} = \int_{t=1}^U e(z^d(t)) dt - z_1^d * U \quad (4)$$

The transport tasks are split between in-house and hired vehicles according to transport demand time series characteristics and vehicle costs. The costs of in-house fleet  $T^{bf}$  consist of  $tcv$  – here called “relatively fixed” costs, which directly depend on the number of  $N^{of}$  and variable costs  $tv$  in equation (5). While  $N^{of}$  is directly related to  $tcv$ ,  $tv$  rather depends on transport volume, i.e., the number of deliveries  $Z^{ofy}$  (Eq. 1). Indirectly,  $tv$  also depends on  $N^{of}$ , through total  $z_1^d$  (Figure 2b). The costs of external transport depend on transport rates. Here it is assumed that all hired carriers have the same freight rates.

$$T^{bf} = tcv * N^{of} + tv * Z^{ofy} \quad (5)$$

$$T^{hc} = th * Z^{hcy} \quad (6)$$

The objective is to minimize transport cost function  $T$ , which consists of total in-house fleet costs  $T^{bf}$  and hired carrier costs  $T^{hc}$ .

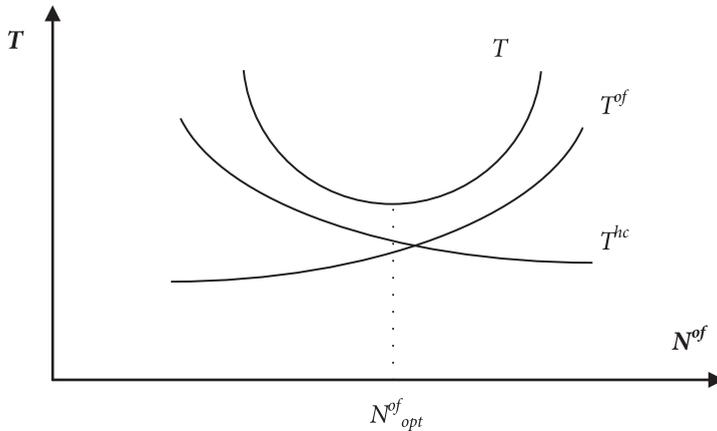
$$T_{min} = \min(T^{bf}(Z^{ofy}), T^{hc}(th, Z^{hcy})) = T^{bf} + T^{hc} \quad (7)$$

Actually, according to Figure 2b,  $U$  is related to the number of in-house vehicles, including the extreme solutions. It can be noticed that  $N^{of}$  can be also expressed as the value of function  $e(z^d(U))$ . Further, the characteristics of  $e(z^d(t))$  also affect the value of  $U$ . One may notice that the higher average  $tg\alpha$  is, the less value of  $U$  can be expected. Otherwise, decreasing  $\alpha$  and  $tg\alpha$  lead ultimately to a uniform function and, consequently, to more days with equal own fleet utilization. Following the conceptual model in Figure 2a, the ultimate goal is to find an optimal  $N_{opt}^{of}$  and, consequently,  $N_{opt}^{hc}$  for  $T_{min}$ :

$$N_{opt}^{of} = F(T_{min}) \quad (8)$$

Following equations (5)-(8), the cost function can be also expressed as a convex function  $T(N^{of})$  (Figure 3). The shape of all cost functions, as well as the position of the extreme value (minimum), strongly depend on the nature of  $e(z^d(t))$ . One may note that it is not necessary that  $T_{min}$  is reached at the point where  $T^{bf} = T^{hc}$ .

**Figure 3:** MAB conceptual model for transport fleet sizing



Finally, it must be noticed that there also exist fixed transport costs, which include administration, infrastructure, etc. They are disregarded in the equations because it is supposed that an administration for transport management exists in both “make” and “buy” cases. They are responsible for this decision and therefore such costs have no effect on MAB decision-making. The relatively variable costs  $tcv$  include all costs generated by one in-house vehicle, including amortization, maintenance, labour costs, etc.

In the next section, a case study of a former oil merchant company, will be used to exemplify the presented method.

#### **4. A CASE STUDY OF AN OIL COMPANY**

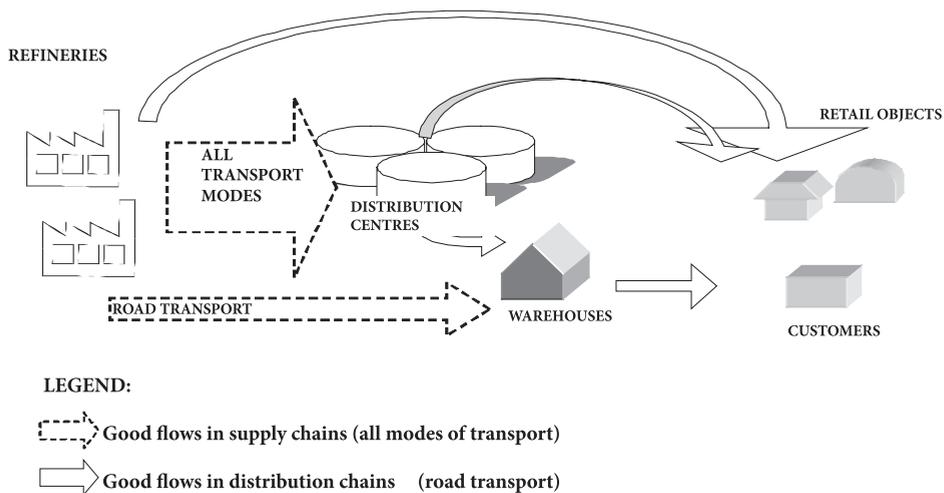
The merchant enterprise NIS-NAP was part of a national oil company, responsible for trade and distribution of oil and oil derivatives. The enterprise has its own truck fleet, but also hires carriers to transport oil derivatives. Since the 1990s, due to privatization and rationalization, it has considered transport capacity and asset outsourcing. This is still an open question even after privatization and changes in the market and the company. In the observed period (1995-2000) it had a recorded transport capacity surplus and considered several solutions, including capacity rationalization, total outsourcing of transport capacities before privatization, merging with another former state oil trading company (Jugopetrol), and sizing common transport resources for a single market, etc.

The vehicles are mostly dedicated to the transport of liquid oil and derivatives and have special equipment. The enterprise is oriented toward a very specialized transport market niche, i.e., high transport asset specificity, according to TCT.

The enterprise has developed its own distribution network, with its own facilities and in-house transport fleet. The main task of the transport function is meeting demand for goods flow in supply and distribution chains. Recently this enterprise has been integrated with another former national oil merchant enterprise that covers the rest of Serbia, Jugopetrol. However, this integration has not affected the described logistics concept and processes in the distribution network.

Road transport is the basic mode of distribution, but also constitutes part of inbound transport (see Fig. 4). It will be considered in the further analysis. The supply chain tiers are mostly consistent and belong to former NIS-NAP (distribution centres, warehouses, and retail outlets), suppliers (refineries), and clients.

**Figure 4:** Supply chain of the oil merchant enterprise NIS-NAP



For further reading about the nature of transport costs see Topencarevic, (1987)

In order to respect the data privacy of this enterprise, only the relatively distant historical database concerning main transport fleet performance and distribution network in the enterprise was used. The aim of this paper is not to explore the current situation in the oil trading company but to exemplify the utility of the

presented method in a real environment and present its outcome in specific conditions.

Demand time series constraints and limitations adopted in the previous section are confirmed by the empirical research, which covers six years. The enterprise has common operational logistics in the total observed period; that is, there is no record of any management action that changes operational characteristics, e.g., time loading or unloading transport units, wasting time on terminals, changing numbers of warehouses or distribution systems, changing gravitation zones, etc.

There has also been recorded an in-house transport capacity excess, as well as enough suitable small carriers in the transport market.

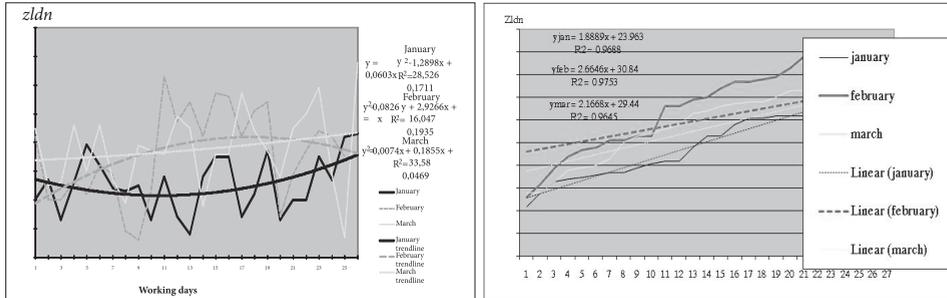
Only so-called “white liquid derivatives” (i.e. gasoline, diesel fuels, kerosene, etc.) were considered to exemplify the described method. This was done for two reasons: due to its significance in goods flow and because most of the in-house transport fleet was dedicated to transporting these derivatives.

#### **4.1 Transport demand characteristics**

The large time transport demand variations in real behaviour are recorded. These variations have been partly related to the transport ordering procedure in the organization (manual scheduling, phone ordering, etc.). Consequently, significant oscillations in transport productivity during the time horizon have been recorded. Therefore, fleet sizing according to the average  $z^d$  values is not acceptable. Also, such conditions make it impossible to meet all transport demands by using in-house truck units, while at the same time reaching high fleet utilization.

The trend lines used for estimating the monthly transport demand time series in the given period have been linear, exponential, logarithmic, polynomial, or power (e.g., see Fig. 5a). In most cases, the best results by polynomial trend lines are showed, because demand reaches its maximum once or more per month. However, we could not find any strong correlation rate between real monthly time series and trend line during the six observed years.

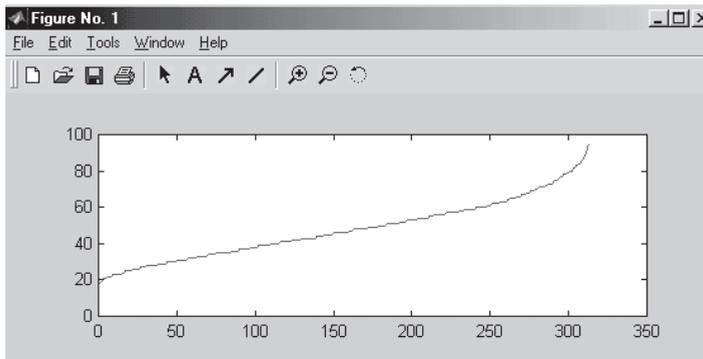
**Figure 5:** Time demand variability in the first quarter of 1996 from oil stations  
 a) real time series and b) time series reordered to non-decreasing orders



Source: Cakić (2002)

Despite such variability, it is possible to predict and simulate time demand characteristics following the methodology, which is described in detail in Cakić (2002). After demand reordering at the annual levels, the values of average  $\Delta z^d$  (Fig. 2b) were about 5%, even in years when sanctions against Yugoslavia caused a high level of business uncertainty. The empirical results also show that a very high rate of correlation between real and simulated monthly time series can be achieved after transport demand reordering ( $R^2 \geq 0,9$ ; with standard error  $s=1-2$  demands per day). Total annual demand reordered time series are simulated in MATLAB 5.3. An example of such a time series is given in Figure 6.

**Figure 6:** Simulated annual time demand series reordered into non-decreasing orders



Source: Cakić (2002)

#### **4.2 Transport capacities for liquid derivatives**

Road transport of white derivatives can be realized either by in-house truck capacity or by carriers' trucks. During the overall observed period (1995-2000) the enterprise had a policy of meeting all transport demands with in-house truck capacity, if possible. In peak periods, it used its own trucks for internal transport demand and hired carriers to complete external transport demand when necessary. Hired carriers transported about 10% of the overall annual transport volume, on average. The transported goods need specialized vehicles, so the possibility for return loads is negligible.

The enterprise's transport fleet size and structure had been adjusted to meet earlier transport needs, and there was evidence of transport capacity surplus in the observed period (Cakić, Nikoličić, 2002). Transportation costs in the model are calculated by using Eq. (5) and the historical database.

The enterprise had medium-term revolving contracts with hired carriers. For the purpose of the model, the transport rates of hired carriers are common and calculated according to public road freight tariff. These rates are determined by average distance and commodity weight (vehicle size per class).

According to the public tariff in the given period, all trucks in the enterprise's fleet can be classified into two types or classes - vehicles up to and vehicles above seven tons of cargo capacity load. However the load capacities of vehicles within a class are still heterogeneous. Therefore, for simplicity's sake, here we have adopted the average loads per vehicle class and the average distances.

### **5. MAIN RESULTS AND DISCUSSION**

The basic MOB economic model (Fig. 1) indicates that economies of scale create a margin where making products or services starts to be cheaper than purchasing them. In the case of transport services, the x-axis is usually transport volume (tons, ton kilometers), or distance (km), while the y-axis is cost. However, this model is rather static and general and cannot describe well the impact of transport demand variability on decision-making. Although many theories are used to explain MOB and, to a lesser extent, MAB decision-making, the most exploited in the literature is TCT. Both TCT principles and Porter's MAB thinking were used as the theoretical ground for building the practical and simple method for MOAB decision-making in transport planning.

The proposed conceptual model in Fig. 3 indicates that there exists an optimal MOAB solution, i.e., optimal in-house fleet size resulting in a minimum of total transport costs. The transport costs of in-house capacity and operations and hired carrier services, as well as demand variability, impact on  $N^{of}$ . The model goes beyond the basic economic MOB model (Fig. 1), because it takes into consideration the stochastic nature of daily transport demand characteristics during the total observed period and allows both extreme and mixed optimal solutions. Still, one of its main values is its simplicity and practical usefulness. Demand reordering allows good visibility of “make” and “buy” areas and the share of days when hired carriers should be engaged during the year. It also supports better forecasting of demand time series (Cakić, 2002), although the purpose of this paper is not an in-depth analysis of the time series forecasting method.

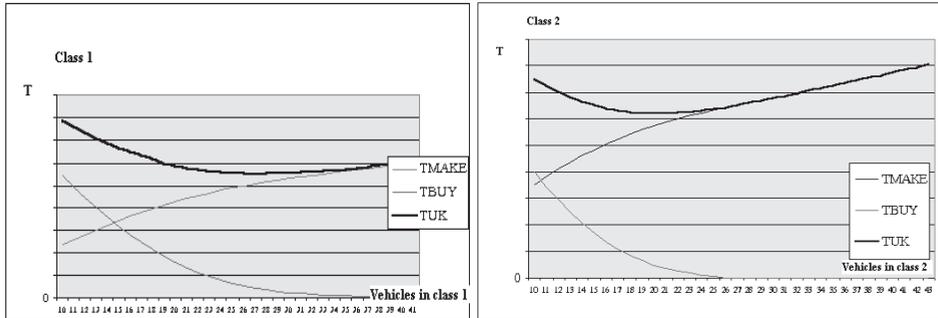
The method described in Section 3 was based on the conceptual model (Fig. 3), which deals with an average volume of transported quantity, i.e., a homogenous in-house and hired fleet. Therefore, the described method deals with average transport costs. However, the transport fleet can be split into groups/classes according to vehicle load capacity. Then the method can be applied to each vehicle class, as is suggested in part 4.2.

Within such conditions, we use the company database for 1996 as an example to calculate the minimum of total annual transport costs, according to the model and equations given in the third section. The hired carrier costs and in-house fleet costs are compared for different  $N^{of}$  and the minimum of total transport costs is determined. The Excel spreadsheet is used to vary the level of  $N^{of}$  and simulate related transport costs. The main results are shown graphically in Figure 7.

The empirical results show that within given circumstances, optimal solutions always include both in-house and hired carriers.  $T_{uk}$  are total transport costs for the given  $N^{of}$ . The simulated results of transport costs related to different in-house fleet/hired carrier combinations for both vehicle classes in our example are shown in graphs in Figure 7. In 1996, the in-house fleet had overcapacity and a rationalization was economically justified in both vehicle classes. However, cost functions had a convex shape, and the minimum is not found in extreme solutions – “make” or “buy”. As a consequence, instead of the well-known MOB concept, decision-making about transport sourcing in the given conditions should rather be within the frame “make and buy”.

**Figure 7 a, b:** Transport costs optimization for both classes in the example:

- a) optimal number of vehicles in Class 1 (<7t capacity load) and
- b) optimal number of vehicles for Class 2 (>7t capacity load)



Source: Cakić (2002)

The calculation was performed for five years (1995-2000), and all results are similar to those presented here, i.e., *Tuk* has a similar shape. The shape of *Tuk* and the position of *Tmin* on *Tuk* indicate the room for fleet rationalization. Still, the fleet sizing cannot be realized only according to one year. The multi-year planning horizon, as well as other company goals (e.g., labour policy) should be considered before the final decision. In 1996 the results of simulation and total calculation show that in-house fleet reduction by almost a quarter (23.8%) implies a decrease in total transport costs of 18.20%. It should be noted that the public tariff rate is used in the model. Although the particular contracts with carriers may contain different rates, their values still impact only on positions of *Tmin* in Fig. 6a and b, while an outsourcing mix continues to be the best solution.

After the proposed fleet reduction, the vehicles with best performances in each class should be kept in the fleet. The proposed conceptual model does not specify which in-house vehicles have to be externalized to reach the optimal solution. As noticed, transport planners have to make this decision according to unit costs per particular in-house vehicle and other relevant indicators and business goals, which are rather qualitative.

In the case of the oil merchant enterprise, the main reasons for preferring the in-house fleet are the cost, within an accepted quality level of service, and market independence. On the other hand, external vehicles can be more flexible and cost less in an uncertain environment with higher demand oscillations.

One may notice here that the obtained results are similar to those of Croucher (1998). Following TCT principles, Croucher (1998) suggests that the use of specialized vehicles, equipment, or expertise seems to be related to in-house distribution. He also emphasizes the relationship between shipment value, tonnage, and transport fleet outsourcing. So, although transport is one of the most outsourced logistics activities (Langley et al., 2010), there is still room to keep transport in-house, or to consider mixed solutions in particular cases. The decision should be based on an in-depth analysis in each particular case and reconsidered periodically.

According to TCT, it was expected that high asset specificity, demand frequency, and uncertainty would imply resource internalization. The model and expected results are mainly in agreement. However, MAB solutions are not well explained by TCT. According to the obtained results, we feel that, in the real environment, the proposed model gives a MAB solution as a rule for stationary systems. The exceptions may be found in volatile markets, or supply chains where products have strongly seasonal characteristics, e.g., supply of agricultural products. There could be several explanations for this. One of them is that mixed solutions give better results than extreme solutions in most situations. The results of an exploratory study show similar results for manufacturing firms. Heriot and Kulkarni (2001) argue that manufacturing firms use intermediate sourcing strategies more frequently than the “polar” strategies, and the most frequent strategy is taper integration.

Over the decades, a continual global trend of logistics outsourcing has been recorded (Langley, 2010). However, TCT stresses three factors that impact on organizational integration and resource internalization: high frequency, uncertainty, and asset specificity. The logistics literature also suggests that with a relatively stable demand, which implies economy of scale, in-house transport capacities may be more cost efficient than hired carriers, especially for short distances (Chopra and Meindl, 2004). The empirical results presented here show how mixed solutions, i.e., MAB, give the best results in practice. Other novel logistics research has also provided practical evidence which shows that it is very important to at least keep in-house expertise and control of outsourced activities (see for example, Wilding and Juriado, 2004 and Aas et al., 2008). Wilding and Juriado (2004) support the idea that outsourcing in logistics should not be treated as an “all or nothing” kind of decision, and that mixed solutions may often give the best results. However mixed solutions are underestimated in logistics research, especially in normative research.

## **6. RESEARCH LIMITATIONS AND IMPLICATIONS**

There are two main areas of limitation in this research: used method and applied theory. Both of them will be briefly highlighted here, before discussing the research implications.

The method described in Section 3 has many limitations. Cost analysis in the model includes the comparison of transport costs depending on “make or buy” transport service decisions. Existing administration and other costs independent of “make-or-buy” decision-making are not considered. The situation was considered where all hired carriers have the same tariff for the same vehicle class. With a little effort, the model could be adapted to analyze a multi-tariff environment. Further, the cost minimization is calculated with many average values. This simplification was suited to exemplifying the main idea, but such an approach decreases the practical value of the described method. Therefore the company calculation should include detailed calculations for each vehicle in the in-house fleet, and an in-depth time and spatial demand analysis of the transport planning.

The value of  $\Delta z^d$  (Fig. 2b) varies within 5% in our example, and so allows a good prediction of the real environment. However, higher values of  $\Delta z^d$  in other enterprises may require method modification and further development. Still, we think that it represents a good basis for development of MOAB models in non-logistic enterprises, particularly in those that already contain a developed in-house fleet and are considering rationalization.

The transaction cost theory used here was revolutionary in economic science, but many authors have also criticized it (e.g., see Heriot and Kulkarni, 2001). It does not consider market conditions, while long contracts and stronger relationships between supplier and buyer are not well explained. It also supposes that the firm works independently from the environment, and ignores the interaction with other organizations: it only focuses on the dyadic relationship between supplier and buyer and individual transactions. Long-term, strategic contracts and “make and buy” solutions are not explained well by this theory. The proposed method includes both the extreme and medium solutions in transport planning, but including more complex arrangements (e.g., joint ventures, horizontal collaboration, etc.) would need more time and effort. Therefore, for all these reasons, the method output should be a valuable, but not a sole criterion in transport fleet planning. The transport planners should utilize it along with other

business and logistic goals and objectives, e.g., with other, qualitative criteria and strategic considerations, before making a final decision.

The example of method implementation in the Serbian oil merchant company NIS-NAP is also shown. Although the presented results relate to the state before the process of company privatization, the question of transport externalization is still topical in the new, privatized company NIS Gazprom Neft, which includes former NIS-NAP. For this and other enterprises, which still have not externalized in-house transport fleets, the proposed method offers the answer from a MOAB perspective.

The method could be helpful primarily for merchant and manufacturing enterprises which already have a private transport fleet and are considering the process of transport externalization. However, it would be relatively easy to improve it and to include in the decision-making the option of investment in new transport capacities. Further practical research could be directed at providing more detail to support MOAB decision-making related to investment.

The research presented here has both practical and theoretical implications. First, the MOAB decision-making process has to be considered and incorporated into firms at the tactical and strategic level of transport planning. The nature of transport demand time and spatial variability strongly affects the most efficient sourcing decision. Therefore, a complex problem is oversimplified if the firms choose only between two extreme solutions. But the managerial challenge is that mixed solutions require more managerial skills than extreme solutions in non-logistic enterprises. Concurrently making and buying is more complicated to manage than solely making or solely buying, due to the buyer having to manage two very different types of suppliers, internal and external (Parmigiani, 2003). Therefore, MOAB decision-making requires a permanent planning and controlling procedure at strategic transport management level.

Second, the paper deals neither with triggers for externalization, nor with details of how to perform the process of externalization. However, as method should be incorporated into the strategic and tactical level of transport planning, it covers a long-term rolling planning period. Therefore it could be expected that a less radical, gradual externalization related to permanent controlling and results evaluation may lead to better solutions.

Third, further research may also be directed towards improving the described weaknesses and limitations of the proposed method. Among the most important

are including the option of investment in new vehicles and assets, and less usage of approximations and average values.

From the theoretical perspective, the obtained empirical results support Porter's rather than the TCT viewpoint, although both of them show some weaknesses. Although TCT explains well why in the case of oil company transport demands should be satisfied internally, it cannot clarify why the optimal solutions are mixed ones for both vehicles classes. Instead of the MOB, the MOAB normative models and methods should be explored and developed in the future. They represent the most comprehensive managerial tool and include both MOB and MAB alternatives. Again, the evaluation of available sourcing solutions has to be permanently incorporated into strategic transport planning.

The results also confirm that further theoretical consideration of logistics and transport outsourcing should pay more attention to mixed solutions. Outsourcing literature points out that cost reduction and company strategy are the main reasons for company outsourcing (Kremić, 2006). Among the main reasons for logistics outsourcing are the focus on core competence and the relationship between service quality and costs and risks (Razzaque, 1997, Rao and Young, 1994). However, although costs are among the main reasons for outsourcing, a dominant trend of transport outsourcing shows that in the past this economic perspective has not always prevailed in decision-making. It would be interesting to better explain this phenomenon in further research. For example, the results presented in this paper could indicate that in transition economies strategy represents a more important reason for transport outsourcing than cost.

## **6. CONCLUSION**

Classical textbook discussions about the make-or-buy problem frame the decision in a world of manufacturing and certainty (Arya et al., 2005). There is evidence of a lack of normative models in MOB and particularly in MAB literature in transport planning. Here a method is described which goes beyond the classical MOB decision-making and represents an attempt to bridge the given gap. Instead of the traditional MOB approach it uses MOAB decision-making in transport planning. The main characteristics of the method are its simplicity and practical value. However it should be developed to obtain more precise calculation without the average values and approximations used for the purpose of this paper, and to include investment in transport capacities in the solutions. The case study

exemplifies how it can be an important and effective managerial tool in non-logistics enterprises.

It is shown that total transport outsourcing may not always be the best solution, although transport capacity is among the most outsourced of logistics resources. The presented research indicates that enterprises should incorporate a MOAB planning mechanism at the strategic level of transport management, and permanently evaluate all sourcing options. This approach requires higher managerial skills from transport planners than do pure “make” or “buy” solutions. Further, the method output should be a valuable, but not a sole criterion in transport fleet planning. The transport planners should consider business and other logistics goals and objectives, e.g., qualitative criteria and strategic considerations, before making a final decision.

Further research could be directed towards improving the method, especially the impact of different time and spatial demand characteristics on the obtained results. Further research could also be more macro-economic oriented. For example, it could compare the role of cost reduction with other factors that affect transport outsourcing in different transition economies.

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