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STRATEGIC VEHICLE FLEET MANAGEMENT - THE MAKE OR BUY PROBLEM

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ABSTRACT. Background: Fleets constitute the most important production means in transportation. Their appropriate management is crucial for all companies having transportation duties. The paper is the first one of a series of three papers that the author dedicates to the strategic vehicle fleet management topic.
Methods: The paper discusses ways of fulfilling company's transportation needs (MAKE-or-BUY problem). It means the choice between using company's own and outside fleet (buying transportation services in a market). The essence of the MAKE-or-BUY problem lies in a time dependency, a seasonal nature of transportation needs. It leads to the MAKE-and-BUY solutions including utilization of both in-house and outside fleets. In the paper an original mathematical model (an optimization method) allowing for the MAKE-and-BUY analysis is proposed.
Results: An application of the proposed optimization method in a real-life decision situation (the case study) within the Polish environment and the obtained solution are presented. The solution shows a low economic justification for using the MAKE option in practice. Especially when a fleet composed of brand new vehicles is considered.
Conclusions: The paper will be continued in two further papers dedicated to strategic vehicle fleet management problems including fleet sizing / composition and fleet replacement.

Key words: management, optimization, fleet, vehicle, transport, make-or-buy.

"Do what you do best, and outsource the rest" - Peter Drucker

INTRODUCTION

The decision if a given business (activity, function - including transport) to carry out using in-house resources, investing capitals, devoting skills, acquiring assets (e.g. fleet), or to outsource it is called a MAKE-or-BUY (MoB) problem.

Both options MAKE and BUY meet company's transportation requirements. However, the basic difference is that in a case of the MAKE option a company acquires transportation means and as a result meets its own transportation requirements. Whereas, in a case of the BUY option a company buys services that meet its own transportation requirements directly. There are a few different organizational ways to take up the MAKE or the BUY option in practice.

As far as the MAKE option is considered the selection of a form of the investment in a company's "own" (in-hose) fleet is crucial. A company's "own" fleet means vehicles owned by a company (included into company's assets when bought for cash, credited, leased or not included when rented) or just staying in company's exclusive disposal.

There are a few vehicle investment forms available in the Polish market [Bakowski and Redmer 2012a, Bakowski and Redmer 2012b]:
– outright purchase,

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- lease (operating or finance),
- credit (with fixed or variable instalments),
- hiring (short or long-term),
- contract trucks.

Considering the BUY option the attention should be given to the number and the size of transportation service providers a company cooperates with. The way services are accounted is also very important. One can distinguish the following solutions occurring in practice based on cooperation with:

- many small-size carriers (an option that usually results in low costs but high organizational involvement; moreover this option does not allow for putting the risk outside, on a service provider - as a result the majority of outsourcing advantages are lost, apart from costs reduction),
- a few mid-size carriers or logistic service providers (an option that usually results in a partial outsourcing only; moreover this option allows for putting the risk outside, on a service provider to some degree and for a partial diversification of the risk and supply sources as well),
- single big-size logistic service provider (an option that results in a full outsourcing including all its advantages and allows for putting the risk outside, on a service provider, but does not allow for a diversification of the risk and supply sources at all).

The results of using the MAKE or the BUY option can be completely different.

The MAKE option may (but not have to) result in lower costs, higher operational flexibility, better adjustment of services to requirements (e.g. specific features of loads, customers, …), but also:

- high capital invested (often under some uncertainty according to the future market situation and the future transportation requirements),
- high fixed costs (including those of unused resources - downtime, empty movements, underutilized vehicles' loading capacity),
- total kilometers to be covered / paid (including those of approaching and back distances),
- full administrative and organizational responsibility (the risk and its costs on a company's side),
- limited operational / delivery range (e.g. caused by driving time regulations),
- sensitivity to the order sizes (small / big), the geographical dispersion of customers (customers located close or far to each other) or locations of customers (e.g. city centers).

On the other hand the BUY option may (but not have to) result in lower costs (cooperation with many small-size carriers) or higher costs as well (cooperation with a single big-size logistic service provider), less administrative and organizational work, possibility to put the risk outside, on a service provider, low capital invested, but also:

- lower operational flexibility,
- decreased control,
- lost organizational experience / skills,
- limited direct contacts with customers.

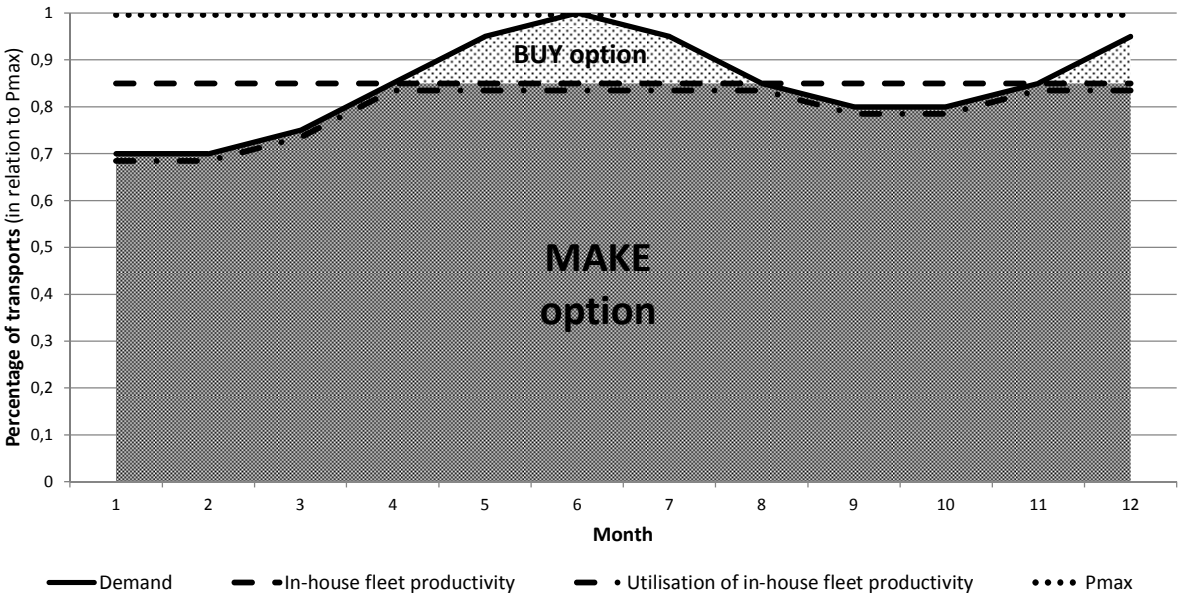
Although discussed above results of using the MAKE or the BUY option can be completely different, the cost effect (savings) based on the Author's experience can reach up to 5-10%, usually no more. So, an assumption that changing the MAKE option to the BUY option or otherwise will result in transportation costs reduction around 20% or more is in the Author's opinion unreal. There are no reasons that buying vehicles and organizing transport on company's own will be significantly cheaper than services delivered by professional carriers (even taking into account their profits). There are also no reasons that carriers buying their vehicles to carry out transportation services and bearing all associated with this costs can provide those services for prices significantly lower than company's in-house costs.

THE METHOD FOR SOLVING THE MOB PROBLEM

There exist not so many methods for solving the MoB problem. All the methods are simple, very similar and based on the economic break-even point or the multi-index (multiobjective) assessment theories. The basic way to decide between the MAKE and the

BUY option is to asses and compare a total costs (quantitative methods [Debinska-Cyran and Gubala 2005, Hines 2004, Jacobs and Chase 2010, Romanow 2003]) or an overall quality (qualitative methods [Debinska-Cyran and Gubala 2005, Min 1998, Trocki 2001, Twarog 2004]) of meeting company's transportation requirements by the both options within assumed time period (usually one year). There are also mixed quantitative-qualitative methods - the trade-off methods combining costs and the quality of the both transportation options, e.g. the method presented by Mankowski [1999].

The general drawback of the mentioned above solution methods is that they are focused on "or" based solutions only. It means that the only one of the both possible transportation options, the MAKE or the BUY, is suggested as the optimal solution. While in practice mixed MAKE-and-BUY (MaB) solutions, based partially on the MAKE and partially on the BUY option are met very often [Parmigiani 2007, Stojanovic et al. 2011] (see Figure 1). Porter [1980] pointed out directly that MaB solutions are very good alternative to a vertical integration strategy since they allow for a better utilization of company's own assets.



Source: author's research

Fig. 1. The mixed MAKE-and-BUY solution concerning seasonal character of a demand for transportation services
Rys. 1. Rozwiązanie mieszane MAKE-and-BUY przy zmiennym sezonowo popycie na przewozy

There arises the question how to find a mixed optimal solution? Not only MAKE or BUY, but MAKE and BUY solution.

The cost calculations for the option MAKE should be based on the TCO - Total Cost of Ownership theory taking into account availability and operating costs of assets (e.g. vehicles). The availability costs are associated with the full readiness of vehicles to work and cover: economic, called also book depreciation (not the tax one), value of capital, drivers' salaries, insurances, taxes, and the other "fixed" costs. Whereas the operating costs are associated with the utilization of vehicles (using them to transport goods) and cover: fuel and other exploitation materials, tires, inspections, services, repairs, and the other "variable" costs depending on a number of kilometers driven. Moreover the cost calculations for the option BUY and partially MAKE (operating costs only) should include seasonal changes of company's transportation requirements resulting in a varying with time (particular periods of analysis) numbers of kilometers covered within both options, MAKE and BUY (see Figure 1).

As a result a generic formula for calculating the total costs of meeting company's whole transportation requirements within an assumed

planning horizon I (divided into periods of analysis i, e.g. months i = 1, 2, 3, …, 12) and under assumed percentage %PWMAX of transports carried out (kilometers covered) using an in-house fleet (within the BUY option) can be written as follows:

$$K_C\left(\%P_W^{MAX}\right) = \sum_{i=1}^{I}\left[\begin{array}{l} Min\left\{P^{MAX}\cdot\%P_W^{MAX}, P_i\right\}\cdot k_W^w + \left\lceil\dfrac{Min\left\{P^{MAX}\cdot\%P_W^{MAX}, P_i\right\}}{W_{Wi}}\right\rceil\cdot k_W^d \\ + Min\left\{P_i - P^{MAX}\cdot\%P_W^{MAX}, 0\right\}\cdot k_O \end{array}\right]$$

where:

$K_C(\%P_W^{MAX})$	the total costs of meeting company's whole transportation requirements within the planning horizon I for a given value of the $\%P_W^{MAX}$ [monetary units – m.u./… e.g. one year],
P_i	company's transportation requirements (demand) within a period of analysis i; i = 1, 2, 3, …, I [kilometers – km, tones – t, ton-kilometers – tkm, pallets – p, m^3, liters – l, routes – r, …/…],
P^{MAX}	the maximum value of company's transportation requirements (demand) within the planning horizon I; $P^{MAX} = Max\{P_i\}$ [km, t, tkm, p, m^3, l, r, …/…],
$\%P_W^{MAX}$	the percentage of the maximum value of company's transportation requirements met by a company's "own" (in-hose) fleet (the MAKE option) [%],
W_{wi}	an average, real productivity of a company's "own" (in-hose) fleet, per one vehicle, within a period of analysis i, expressed in the same units of measurement as company's transportation requirements (the MAKE option) [km, t, tkm, p, m^3, l, r, …/…],
k_W^w	the unit operating costs of a company's "own" (in-hose) fleet, per one vehicle and unit productivity (the MAKE option) [m.u./ km, t, tkm, p, m^3, l, r, …],
k_W^d	the total availability costs of a company's "own" (in-hose) fleet, per one vehicle within a whole planning horizon I (the MAKE option) [m.u./…],
k_O	the unit costs of buying transportation services in the market to meet company's transportation requirements (the BUY option) [m.u./ km, t, tkm, p, m^3, l, r, …],
$\lceil\ldots\rceil$	the rounding up to integer symbol,
$Min\{\ldots\}$	the minimum value of elements of a set.

THE CASE STUDY - SOLVING THE MOB PROBLEM IN POLISH CIRCUMSTANCES

A big trading company operating in the Polish market utilizes warehouses located all over the Polish territory. The company transports about 300 thousand tons of goods annually from warehouses to the customers using outside vehicles (the BUY option). To fulfill bigger orders from the customers (FTL) the company cooperates with many small-size carriers (operating medium and heavy duty vehicles characterized by 10 and 20 ton load capacities respectively - the capacity is utilized in 90% on average). Whereas to fulfill small orders from the customers (LTL) the company cooperates with a single big-size logistic service provider. About 85% of loads (taking into account their weight) are transported by small-size carriers, the remaining 15% by the logistic service provider. It gives about 11 million kilometers in total covered by small-size carriers annually (9 million of them are loaded kilometers being paid and resulting in the cost of 8 million dollars annually). There is no information about kilometers covered by the logistic service provider since its services are accounted based on the weight of loads delivered to the customers (per one tone irrespectively of a destination but depending on the total amount of tones transported - discounts). Company's transportation requirements vary about 15% of the weight of transported loads month to month.

The presented case is the most difficult one from the three possible decision situations when solving the MoB problem. It is the case where a company takes up the BUY option only using outside carriers to meet its own whole transportation requirements. In such a case the availability of necessary data to solve the MoB problem is very limited. The two other possible decision situations are the MAKE option and the mixed (MAKE-and-BUY) one. In such decision situations the

availability of data are usually better. In the first case, where a company currently takes up the BUY option only, the most difficult part of the analysis is to calculate costs of the option DO. It requires an estimation of a total number of kilometers to be covered by a perspective company's "own" (in-house) fleet. This number depends on a particular amount of loads to be delivered to customers having particular locations taking into account sizes and frequency of their orders (deliveries as well).

It is worthwhile to mention that there appeared some limitations when solving MoB problem in the presented case study. On the one hand, transporting small size loads (LTL) by the logistic service provider turned out to be the most expensive option (taking into account transportation costs calculated per one tone of loads). But, on the other hand, it turned out to be impossible to transport them using an in-house fleet or outside but small carriers since it results in routes with too many destination points. Such routes are very ineffective and cause problems with deliveries on time (fulfilling time window constraints).

For the described above MoB problem a mathematical model has been constructed to optimize (minimize) a total transportation costs under the all possible combinations of MAKE and BUY options, their share in meeting the whole transportation requirements of the company. The MAKE option has been based on brand new or used medium and heavy duty vehicles, whereas the option BUY has been based on small-size, local carriers and the logistic service provider. The share of MAKE and BUY options in meeting the whole transportation requirements has been defined as the percentage of the total weight of all loads transported within the given option (changing the share by 10% from 0 to 100%). As a result 112 combinations defining potential solutions of the MoB problem has been analyzed. Starting from the 100% of the MAKE option / 0% of the BUY option - small carriers / 0% of the BUY option - logistic service provider solution, through the all combinations of these numbers, including the current one solution that is the 0% of the MAKE option / 85% of the BUY option - small carriers / 15% of the BUY option - logistic service provider.

Obtained feasible solutions of the MoB problem in the analyzed case (see Figure 2) can result in a reduction of the total transportation costs by 16% but also in an increase of the costs by even 34% in comparison to the current solution. Moreover, the three characteristic solutions of the problem, which are the cheapest, the most expensive and the current one include the same fundamental assumption: 0% of the MAKE option / 100% of the BUY option. Thus the share of small carriers and the logistic service provider within the BUY option appears to be crucial. The cheapest solution assumes the 100% share of small carriers in the option BUY, whereas the most expensive solution assumes the 100% share of logistic service provider. It is coherent with a common opinion about the transportation market in Poland, according to which, looking for the cheapest transportation solution, not necessarily the most convenient (high organizational involvement, no chance for putting the risk and the responsibility on a service provider), companies should use small, local carriers. Whereas, looking for the solution not necessarily cheap, but the most convenient, assuring good quality, full service, low organizational involvement and a chance for putting the risk and the responsibility on a service provider, companies should cooperate with only one logistic service provider. At least with a few, but it can result in higher costs.

And finally, as for the MAKE option based on company's "own", brand new vehicles it allows for the significant costs reduction as well. In the analyzed case it was about 10% cost reduction when transporting 90% of loads by company's own fleet and the remaining 10% by the logistic service provider - small, fragmented orders from scattered customers, orders difficult to fulfill by the in-house fleet. However, such the solution requires significant investments and as a result it should be considered as a very risky. The better solution seems to be the MAKE option based on company's "own" used vehicles resulting in 14% costs reduction achieved with significantly lower investments.

Source: author's research based on the real life data

Fig. 2. The total transportation costs v. the share of options MAKE and BUY - small, local carriers and logistic service provider (the black square denominates current transportation solution; black and white circles denominate the cheapest and the most expensive solutions respectively)

Rys. 2. Całkowite koszty przewozów a udział w ich realizacji opcji MAKE i BUY - mali, lokalni przewoźnicy i duży operator logistyczny (czarnym kwadratem zaznaczono rozwiązanie obecne; czarnym i białym kółkiem odpowiednio rozwiązanie najdroższe i najtańsze)

The carried out sensitivity analysis revealed that even 5% increase of the unit operating costs of a company's "own" vehicles reduces the savings resulting from the MAKE option (assuming brand new vehicles in the fleet only) from 10 to less than 7%. Moreover there is a risk associated with an ineffective utilization of the fleet in the future (the necessity of managing the fleet, but especially the necessity to assure an appropriate vehicles' mileage utilization - number of kilometers driven and vehicles' capacity utilization).

CONCLUSIONS

The MoB decision concerning transportation solutions based on company's "own" vehicles or outside services belongs to the group of strategic fleet management problems. This decision, as any other strategic decision, concerns relatively long-term planning horizon and nas postponed in time effects. It means that to asses if the decision made is correct or wrong will be possible after a long time (half a year to one year). Moreover, such decisions are usually crucial for a company and their results that are noticeable outside a company, have an economical character (e.g. investments). That is the cause why it is very important to make this type of decisions not only intuitively, but first of all based on comprehensive and correct analysis. Unfortunately in the literature MoB solution methods are described very superficially and only those which lead to “black or with” solutions, it means 100% of the MAKE or 100% of the BUY option only. But the key to solve the MoB problem lies in mixed MAKE-and-BUY solutions.

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STRATEGICZNE ZARZĄDZANIE TABOREM SAMOCHODOWYM - PROBLEM MAKE-OR-BUY

STRESZCZENIE. **Wstęp:** Floty pojazdów stanowią podstawowy środek produkcji w transporcie. Prawidłowe zarządzanie nimi jest zatem kluczowe dla wszystkich firm realizujących przewozy. Niniejszy artykuł jest pierwszym z serii trzech, jakie Autor chce poświęcić tematyce strategicznego zarządzania taborem samochodowym.
Metody: W artykule omówiono sposoby zaspokajania potrzeb przewozowych przedsiębiorstw (problem MAKE-or-BUY). To znaczy wybór pomiędzy wykorzystaniem własnych środków transportu i/lub zakupem usług przewozowych na rynku. Istota problemu MAKE-or-BUY leży w aspekcie zmienności w czasie, sezonowości potrzeb przewozowych przedsiębiorstw. Prowadzi to do rozwiązań typu MAKE-and-BUY obejmujących jednoczesne wykorzystanie transportu własnego i obcego. W artykule zaproponowano autorską metodę (model optymalizacyjny) pozwalającą na prowadzenie analiz typu MAKE-and-BUY.

Rezultaty: W artykule zaprezentowano zastosowanie opracowanej metody na rzeczywistym przykładzie problemu decyzyjnego w warunkach polskich oraz uzyskane rezultaty. Rezultaty te pokazały brak ekonomicznego uzasadnienia dla zastosowania opcji MAKE w polskiej praktyce gospodarczej. Szczególnie w przypadku, gdy rozwiązanie to miałoby być oparte o tabor złożony z pojazdów fabrycznie nowych.
Wnioski: Niniejszy artykuł będzie kontynuowany w dwu kolejnych artykułach Autora, poświęconych strategicznemu zarządzaniu taborem samochodowym, w tym kwestii jego liczebności / składu oraz wymiany.

Słowa kluczowe: zarządzanie, optymalizacja, flota, pojazd, transport, make-or-buy

STRATEGISCHES FAHRZEUGFLOTTEN-MANAGEMENT - DAS MAKE-OR-BUY PROBLEM

ZUSAMMENFASSUNG. Einleitung: Fahrzeugflotten und Fuhrparks stellen grundlegende Produktionsmittel innerhalb des Transportes dar. Daher ist ein angemessenes Flottenmanagement für alle Unternehmen und Firmen mit Transportaufgaben von großem Belang. Der vorliegende Artikel ist der erste von dreien, die der Autor dem strategischen Fahrzeugflotten-Management widmet.
Methoden: Dieser Artikel beschreibt Möglichkeiten für die Abdeckung des Transportbedarfes im Unternehmen (Make-or-Buy-Problem). Hierbei besteht also die Möglichkeit, Transportleistungen mit einer eigenen Flotte selbst zu erbringen oder sie extern einzukaufen. Die Hauptaspekte des Make-or-Buy-Problems liegen dabei in der Zeitabhängigkeit, bzw. in den saisonalen Schwankungen bezüglich des Bedarfs nach Transportleistungen. Dies führt zu Make-and-Buy-Lösungen, die auf eine Kombination von internen und externen Flottenlösungen setzen. Im vorliegenden Artikel wird ein mathematisches Optimierungsmodell zur Make-and-Buy-Analyse vorgestellt**.**
Ergebnisse: Es werden die Umsetzung und Ergebnisse einer Anwendung der vorgestellten Optimierungsmethode im Rahmen eines Feldversuchs in Polen präsentiert. Die Lösung zeigt auf, dass die wirtschaftliche Begründung für die Make-Entscheidungen in der polnischen Wirtschaftspraxis ausbleibt. Dies trifft insbesondere zu, wenn dieser Lösung der Einsatz einer Flotte von fabrikneuen Fahrzeugen zugrundeliegen sollte**.**
Fazit: Conclusions: The paper will be continued in two further papers dedicated to strategic vehicle fleet management problems including fleet sizing / composition and fleet replacement. Dieser Artikel wird durch zwei weitere Artikel zum Thema strategisches Flottenmanagement ergänzt, welche dann die Fragestellungen der Flottengröße und -zusammenstellung sowie des Flottenersatzes behandeln.

Codewörter: Management, Optimierung, Fahrzeugflotten, Fahrzeuge, Transport, Verkehr, Make-or-Buy, Make-and-Buy**.**

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