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Method for Transportation Cost Calculation on the Basis of Full Cycle (Round Trip)

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Abstract

Background/Objectives: This paper considers the issue of transportation cost calculation in terms of a "Full Truck Load, FTL" model for the "to and fro" trip which is called a "round trip". **Methods/Statistical analysis:** The authors applied statistical analysis to determine all the possible options of round trips for a specific direction that have already been carried out by a particular transport company, to break them down into component parts, to calculate the cost of each of them and to receive a general assessment of the profitability/unprofitability of the round trip. **Findings:** The paper has studied all the main types of round trips and gives examples of them with a detailed analysis of their sectors. The authors have analyzed the factors influencing the transportation costs, as well as fixed and variable costs as a basic set of parameters for the cost calculation. The formula for the calculation of these parameters is given based on the experience of logisticians and dispatchers of large transport companies. As a result of this study, the authors have proposed a new method for calculation of transportation cost according to the round trip statistical analysis data. The study and analysis of statistical data on return variants of specific transport companies have allowed identifying some characteristics, according to which a starting point of return can be considered the metropolitan region of departure of the means of transportation mainly for "income producing" trips to another area, and the end point of return can be considered the point of next entry of the means of transportation in the metropolitan region. **Application/Improvements:** This method makes it possible to get a proper assessment of profitability or unprofitability of a transportation direction taking into account the accumulated traffic statistics regarding a particular transport company.

Keywords: Full Truck Load (FTL), Round Trip, Transportation, Vehicle Routing Problem (VRP)

1. Introduction

The problem of transportation optimization (Vehicle Routing Problem, VRP), was first described in[1], is a very important task of modern optimization theory. Classification of optimization problems of transport logistics is given in[2-4]. In this paper we consider a special VRP problem of truck distribution as per orders for large transport companies managing a fleet of large trucks. Such transport companies are widespread in countries with a large territory and the length of roads (Russia, USA, Canada, India, and others) and carry out inter-regional Full Truck Load (FTL) transportation. Various models of organization of FTL cargo transportation are given in[5]. Analysis and methods for solving such problems are considered in[6]. Such transportations are characterized by direct contracts between the carrier and customers for booking a whole truck without the need to take into account the cargo volume and map consolidated routes. However, despite this simplification, such transportations have their own specific challenges consisting in choosing the right strategy for the implementation of cargo transportation in various directions. The transport company permanently deals with the issue of profitable directions in order to maximize revenues and minimize costs. This task may be solved using the automated Fleet Management Systems (FMS) which can process a large volume of data on the company's transportations in any direction and issue the necessary analytics. At the moment, the most advanced FMS systems are those based on multi-agent technology[7,8]. They provide not only the analytical data, but also the ability to automatically make

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decisions based on statistics obtained. Using a multi-agent management system, the authors have analyzed the characteristics of the key unit of FTL transportation analysis: round trip.

2. Concept Headings

2.1 Problem Definition

The problem to be solved is the one of a priori analysis of transportation. The main difficulty lies in the fact that we know only orders and potential "to" transportation costs (direct trip, for example, from Moscow to Yekaterinburg), but we do not know the "fro" orders, they have to be found along the path of the means of transportation (MT), and there may be no orders at all on the way back and the truck would have to go empty, so there would be no profits from the direct trip. And the return trip of the MT to the point of departure can be very long and difficult, because the aim of the company is not to return the truck to the base as soon as possible, but to increase the revenue per day for every kilometer of a particular trip. But of course, the truck should eventually return to base: to get refueled, to deliver and receive documents, to shift the driver or change the trailer, for repair and so on, but coming back is not its main goal. As a result, there is the problem of estimating the potential costs, not only for the "to" trip, but for the whole "round trip". At that rate, it is important to analyze the statistics of all the possible options of round trips for a specific direction that have already been carried out by a particular transport company, to break them down into component parts, to calculate the cost of each of them and to receive a general assessment of the profitability/unprofitability of the round trip.

2.2 Components of Transportation Costs

The calculation of the expected cost of transportation for a particular direction (city or region) in particular transport company is carried out daily by experienced employees of logistics and economic departments. The main question is what should be included in the transportation cost of this trip and what is to be moved to the next one, because there are no specific rules for that.

Unexpected deviations from the planned route often occur during the trip for the following reasons:

- stopping at the base during the trip for some reasons (dismissal or shifting of the driver, repair, delivery of previous trip documents by the driver, etc.)
- stopping in a different place for refueling at the reliable gas station
- stopping in an additional place for loading or unloading
- driver's mistake

According to results of post factum analysis of causes of deviations, each specific transport company decides what to consider and what to ignore, as for every trip there is always a plan and the post factum situation. So, there is always something that is definitely clear and can be included in the plan, but there is also something that will be known only afterwards and can never be planned. However, there are two basic types of costs used by almost all companies: variable and fixed costs.

Variable costs depend on the distance and in most cases are related to the cost and consumption of Petroleum, Oil and Lubricants (POL) and Maintenance Service (MS) per kilometer of route. They may be calculated using various calculating methods, but in general everybody count M rubles for 1 km. At the same time, somebody may specify the costs for 1 km of empty car trip (without load) and useful trip (loaded). The basic approach to the calculation of the path length for a specific trip is the following: the distance from the place of the previous unloading to the loading place plus the distance from the loading place to the unloading place.

Fixed costs depend on the operating time of the vehicle during the trip, without mentioning whether the vehicle is moving or standing still. These costs relate to the salary of the driver, the vehicle lease payments for buying it out, insurance, payment of the vehicle satellite tracking system, etc., which are conventionally counted as T rubles per day. As per the basic approach, the transportation time calculation starts from the date of unloading of the previous order and ends at the moment of unloading of the current order. Therefore, in a first approximation, the cost of transportation is the usage of vehicle counted in km * M plus usage of vehicle counted in days * T. After that, each company decides what to include in additional costs, depending on its experience and knowledge of characteristics of a particular direction, which determine the effectiveness of the company's business.

2.3 Round Trips

The cost of the "fro" trip of the truck is calculated by the following algorithm. The whole "to and fro" trip may consist of several trips and is called a round trip.

If we analyze the market pricing system in Russia, we may notice an interesting pattern: the cost of almost all "fro" trips to Moscow and other major cities carried out according to the tariff paid by the customer is below the cost for a transport company that carries it out, with the exception of St. Petersburg, Smolensk and several other cities.

For example, the truck carries out the transportation by order from Volgodonsk to Salsk-Esipovo, to do that it should cover a distance of 1483 km. Approximate cost of such transportation: 33,000-35,000, but the tariff for the client is 27,000. It is clear that this transportation is loss making for the company. But in fact this is an example of so-called "compensatory" trip. It does not bring revenue to the company, but it compensates its costs of the trip back to a major metropolitan city (Moscow) from where the vehicle carried out its "income producing" order and earned the main revenue. Therefore, in most cases compensatory trips are unprofitable, may be below cost and lossmaking. But if we consider the whole circle covered by the vehicle when performing Salsk-Esipovo trip, then it was probably like this:

- Esipovo-St. Petersburg: "compensatory" trip;
- St. Petersburg-Kamennogorsk, empty run;
- Kamennogorsk-Volgodonsk, "income producing" trip;
- Volgodonsk-Salsk, empty run;
- Salsk-Esipovo, "compensatory" trip.

We should also mention the "local" trips, i.e. short trips within a large city, in which the structure of tariff for the customer is totally different: the number of working hours, plus dispatching and return hours multiplied by the tariff rate per hour; and in terms of cost: fixed costs per day, wage for the driver, averaged kilometer age per day according to the truck run tariff. It is rather a special case, but it also contributes to the calculation of the cost of return trip. I.e. one of the main points of the analysis of the return trip cost is its division into the following sectors: "income producing", "compensatory" and "local".

2.3.1 Analysis of the Main Types of Round Trips

The types of round trips and their sectorization can be seen in the following examples:

Example 1. The circle begins and ends at the base in Elektrostal city. Dispatching from the base in Pushkino is included in the Pushkino-Voronezh trip, and the return to the base from Solnechnogorsk is included in the Voronezh-Solnechnogorsk trip (Figure 1).

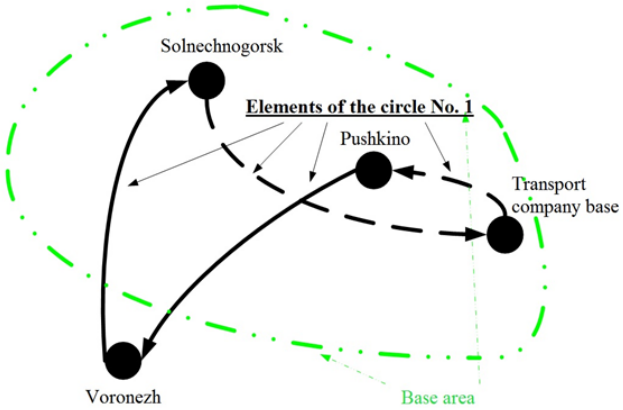

Figure 1. Circle with a stop at the base.

Example 2. The circle starts at the Maintenance Service Station (MSS) and ends at the base. Dispatching from the service station in Pushkino is included in the Pushkino-Voronezh trip, and return to the base from Solnechnogorsk is included in the Voronezh-Solnechnogorsk trip (Figure 2.).

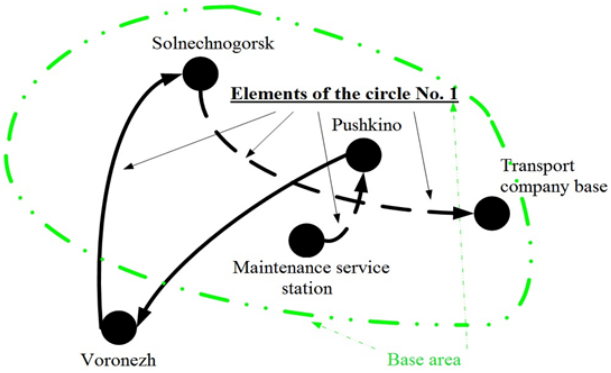

Figure 2. Circle with a stop at the maintenance service station.

Example 3. The circle No.1 begins, and the round trip No.2 ends at the base. Dispatching from the service station in Pushkino is included in the Pushkino-Voronezh trip (circle No. 1), the dispatching from Solnechnogorsk to Domodedovo is included in the Domodedovo-Rostov-on-Don trip (circle No. 2) and the return to the base from Ruza is included in the Azov-Ruza trip (circle No. 2) (Figure 3).

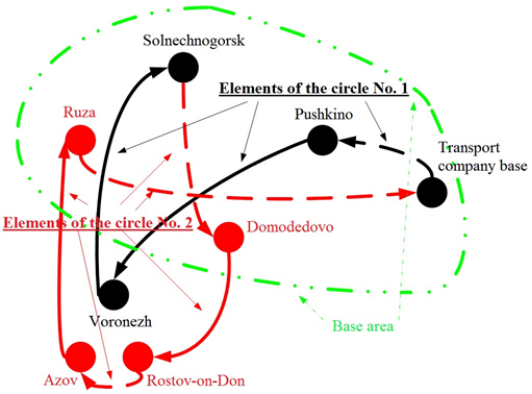

Figure 3. Round trip containing two circles.

Example 4. One large circle without stopping at the base. Dispatching from Podolsk to Korolyov in included in the Korolev-Volgograd trip, and dispatching from Yekaterinburg to Krasnokamsk is included in the Krasnokamsk-Yaroslavl trip (Figure 4).

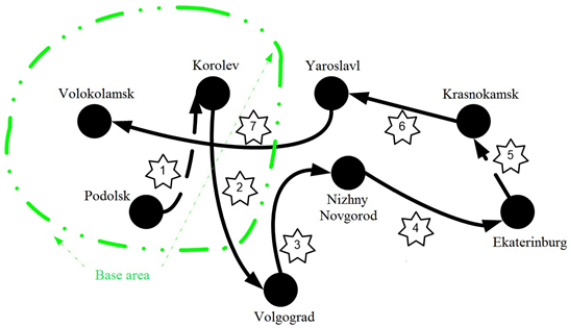

Figure 4. Large circle without stopping at the base.

Example 5. Two circles without stopping at the base. Dispatching from Podolsk to Pushkino is included in the Pushkino-Voronezh trip (circle No. 1), and the dispatching from Solnechnogorsk to Domodedovo is included in the Domodedovo- Rostov-on-Don trip (circle No. 2) (Figure 5).

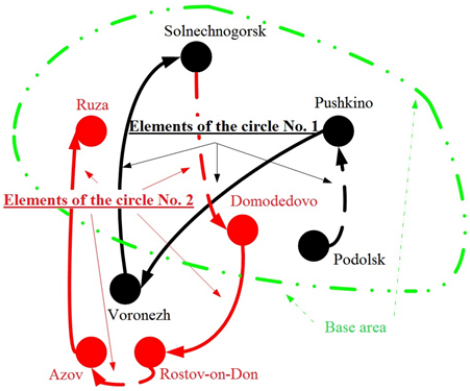

Figure 5. Two large circles without stopping at the base.

Example 6. Local trip during the carrying out of the other trip. An order is taken in Domodedovo to be brought to Samarskoe, an additional loading of freight for Samarskoe is planned to be in Venyov, but there is one more order from Domodedovo to Venyov (Figure 6).

Figure 6. Local trip during the carrying out of the other trip.

Example 7. Internal circle. MT arrived in Perm within the circle that began as the Pushkino-Yekaterinburg trip, but there is an order for the internal Perm-Taganrog-Perm circle (Figure 7).

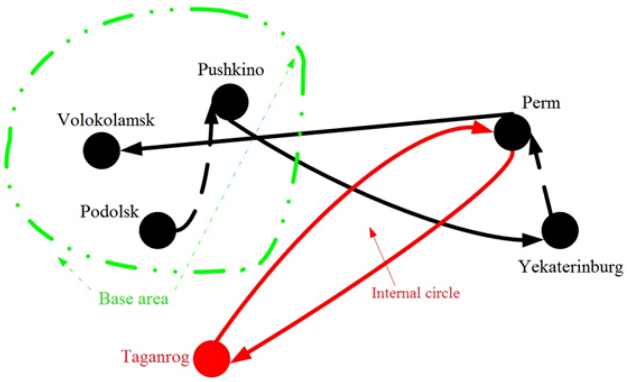

Figure 7. Internal circle.

Example 8. Local trip within the base area during the large circle trip. During the Perm-Volokolamsk trip the truck stopped at the base, detached the loaded semi-trailer, attached another semi-trailer and performed a local trip within the base area (Figure 8).

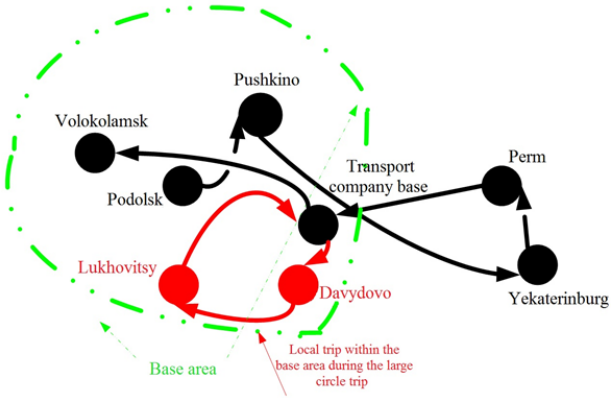

Figure 8. Local trip within the base area during the large circle trip.

Example 9. Local trip outside the base area during the large circle trip. Upon execution of the Pushkino-Nizhny Novgorod trip, the truck performs a trip within the city before continuation of the circle (Figure 9).

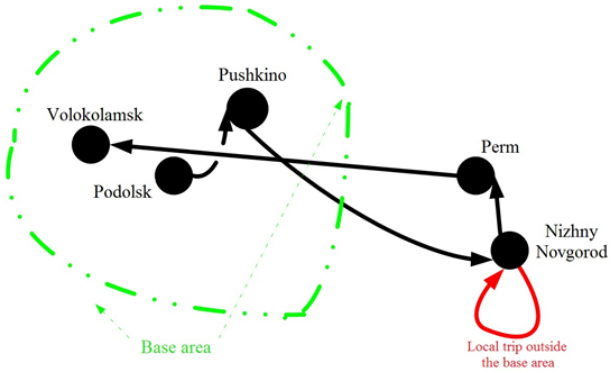

Figure 9. Local trip outside the base area during the large circle trip.

In the above examples we can see that it is often very difficult to understand, where the direct trip is completed and the vehicle begins to return in the base area. For example, there is no direct way to return from Yekaterinburg to Moscow (or if yes, it is unlikely or it is not profitable, because it is more profitable to return by more complex route), but the truck goes empty to Tver, in Tver it takes a freight for Nizhny Novgorod from Nizhny Novgorod it goes empty in another city, and only after that it will return to the Moscow region, which can be considered a departure point. There may be a lot of such ways to return for each Moscow-Region trip. The study and analysis of statistical data on return variants of specific transport companies have allowed identifying some characteristics, according to which a starting point of return can be considered the metropolitan region of departure of the MT mainly for "income producing" trips to another area, and the end point of return can be considered the point of next entry of the MT in the metropolitan region.

2.3.2 Method for the Round Trip Cost Calculation

On the basis of these provisions, for the calculation of the cost of return from each locality the following method has been developed:

- All the cities, which have ever been involved in transportation activity of a specific transport company, are selected and each city is designated as the N city.
- All orders, where N is a city of departure (i.e., the city from which the empty truck departs or, as a special case, where it starts the loading as per the order) are selected, then all of these orders are sorted by MT.
- For each MT in the group, the following orders in its historical chain of orders are identified. The end of the chain (the circle) is fact of entering of the MT in the area of the metropolitan city (Moscow, St. Petersburg, etc.).
- For each of such chains from the obtained taking out, we can get 3 average parameters for the expected return from N city: by adding together all the amounts of chain orders we obtain the average return revenue, by adding together all the chain orders runs (empty and loaded) we get the average return run, by calculating the total time of all chain orders we obtain the average time of return. Thus, we get 3 average parameters to assess the return from the N city, which are recorded in the N city statistics. The average return run and average time of return to the circle are compared to variable and fixed costs. If we subtract from the circle revenue the variable and fixed costs, we get the profit (loss) of the round trip.

If the number of return chains found is less or equal to the minimum allowed parameter (it is preliminarily assumed to be 3), then the statistics of the return from the city is considered "weak" and it is not taken into account. Instead, we shall find a nearest "strong" statistics city and take its return parameters with the addition of time and costs for an empty trip to this city.

3. Results

As a result of this study, the statistical method of a priori assessment the cost of the full truck load (FTL) transportation. This method has been tested using the real data of Monopoly Transport Company[9]. Employees

of the Monopoly Company have confirmed the validity of the results and use this technique in their daily work.

4. Discussion

As a result of the study, the scientific method of a priori assessment of the cost of transportation has been first developed on the basis of knowledge and experience of people working in the field of transport logistics, not only on the basis of abstract research of the generalized VRP problem. This approach may be easily applied when solving the real-world business problems of transport companies. At the same time, the developed method is not contrary to the general VRP problem. It completes it allowing more accurate specifying the initial data on the cost of transportation in various directions, taking into account the already accumulated statistics on completed round trips.

5. Conclusion

The work is part of a larger study in the development of network-centric model of interaction of adaptive schedulers of resources to support the coordinated work of the federation (group) of the regional transport companies and to increase the efficiency of long-distance freight transportation. Method of calculation of the cost of return trip for different localities proposed in this paper is used in the transportation cost assessment carried out by adaptive multi-agent planning systems, which evaluate the various ways of transportation by different transport companies within the group, each of which has its own cost of performing a specific order. As a result, the planning systems can "come to an agreement" between themselves and pass the order for fulfillment by the company, which in the current market conditions has the lowest cost in this direction.

6. Acknowledgement

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