www.engineeringscience.rs

JOURNAL OF APPLIED ENGINEERING SCIENCE

JAES

ISTRAŽIVANJA I PROJEKTOVANJA ZA PRIVREDU

Indexed by

PICKUP AND DELIVERY COSTS - A PROPOSED OUTSOURCING MODEL BASED ON THE NUMBER OF STOPS

Amel Kosovac
Faculty of Traffic and Communications, University of Sarajevo, Sarajevo, Bosnia and Herzegovina

Ermin Muharemović
Faculty of Traffic and Communications, University of Sarajevo, Sarajevo, Bosnia and Herzegovina

Key words: *outsourcing, model, stop, costs, pickup, delivery*

Cite article:
Amel, K., & Ermin, M. [2021]. Pickup and delivery costs - a proposed outsourcing model based on the number of stops. *Journal of Applied Engineering Science*, 19(2) 270 - 274. DOI:10.5937/jaes0-28450

Online aceess *of full paper is available at:* www.engineeringscience.rs/browse-issues

Original Scientific Paper

Journal of Applied Engineering Science
Istrazivanja i projektovanja za privredu

doi:10.5937/jaes0-28450

Paper number: 19(2021)2, 791, 270-274

PICKUP AND DELIVERY COSTS - A PROPOSED OUTSOURCING MODEL BASED ON THE NUMBER OF STOPS

*Amel Kosovac, Ermin Muharemović**
Faculty of Traffic and Communications, University of Sarajevo, Sarajevo, Bosnia and Herzegovina

The active introduction and modern technologies application in the transport market greatly affect all transport branches and the ways of their business. Availability and mass usage of the internet and web services create a new ambiance of trade through online sales and e-commerce. The increase in internet sales has a direct effect on the business of courier companies. The number of shipments in the B2C (Business-to-Consumer) segment is growing and putting an increasing pressure on costs for companies that perform pickup and delivery. Companies are trying to adapt their business to the new challenges and conditions that prevail in the transport market through different cost management models. One way to manage costs is to outsource costs. This paper proposes a model cost calculation in outsourcing services for pickup and delivery shipments based on the number of stops.

Key words: outsourcing, model, stop, costs, pickup, delivery

INTRODUCTION

The Internet and the digital revolution are fundamentally changing the worlds of communications, business and commerce. The digital economy continues to grow rapidly.

The usage of smartphones has become an unavoidable factor in bringing companies closer to users in the digital age.

Using Wi-Fi and mobile internet, users use smartphones to perform various business activities through various applications and, increasingly, for online shopping. Different customer requirements, especially in the 2C segment, the short product life cycle but also the electronic way of trading goods directly affect the increase in the number of consignments. Courier companies are under increasing pressure because customers demand that goods be delivered on time, in the right quantity and quality, in the right place with a minimum price.

This way of trade and requests from users have a direct effect that transport prices do not increase in proportion to the number of shipments [1]. In these business conditions, costs grow faster than revenues, so the management of courier companies is facing great challenges. How to reduce fixed costs and bring cost changes closer to revenue changes, especially during periods of volume fluctuation? Courier companies are trying to adjust their business and reduce costs through certain restructurings, the introduction of new delivery methods such as delivery machines, optimization of vehicle movement, network reorganization, outsourcing, etc [2].

Special attention is required for research that predicts a sudden number of shipments for delivery in developed markets [3]. So it is necessary to adjust strategies, technology, and costs to mitigate the challenges that will be posed to operators.

Shipments that arose from e-commerce are mostly delivered to the inner city zones, where the challenges for courier companies are especially related to the aspect of infrastructural limitations, but also the aspect of environmental protection.

A high percentage of operating costs, as well as the total costs of postal companies, arise from the pickup and delivery phase, which account for 57% of total operating costs [4]. On the other hand, the sorting and line hole phases account for about 43% of total operating costs.

The paper aims to propose a specific model of outsourcing costs in the phase of pickup and delivery of shipments, which uses the number of vehicle stops on the route for the calculation. A 'stop' is referred to the stop that the vehicle makes for pickup or delivery of at least one shipment. The shipment must have at least one package or pallet in its composition.

SIGNIFICANCE OF OUTSOURCING

Outsourcing is considered to be the main tool on how to arrive at variable costs in terms of increasing or decreasing volume in postal companies [5]. Its main advantage is the conversion of the company's fixed costs into variable costs in the form of the purchase price[6], [5].

In the postal companies, outsourcing is done using a certain model, which uses specific input factors such as the number of shipments, number of packages, weight, etc.

Certain research conducted for outsourcing [6], based on the results after the outsourcing, shows that companies have managed to reduce their costs by 9%. In parallel, the postal companies managed to improve the quality of service provision by 15% and increase capacity by 15% [6], [7].

The authors [8], [9] use a model based on input parameters for average time per stop, the average distance

*ermin.muharemovic@fsk.unsa.ba

from the warehouse to the first stop, the distance between stops, as well as the average speed of movement. However, it is very difficult to monitor and measure all the listed parameters necessary for the model.

On the other hand, the author [10] created a model for evaluating operations in the first and the last phase in terms of outsourcing, in order to monitor the quality and performance of tasks. The author proposes certain parameters through which the external organization would be monitored. These parameters are key performance indicators - PKPI and quality of services key performance indicators - QKPI. The parameters monitored through the PKPI are the number of stops per hour during the first and last phase operations, while the QKPI implies 6 sub-KPIs. This paper does not take into account the calculation of costs, but it can be considered to a significant degree when creating a partnership with respect to the outsourcing agreement.

Another reason why postal companies are increasingly outsourcing is the transfer of the risk of transporting shipments to a third party [7].

The paper deals with defining the method of calculating outsourcing costs based on the number of stops in the first and last phase of the shipment delivery process, and provides an example.

When drafting an outsourcing partnership agreement, it is necessary to separate the costs for the execution of services from the performance and quality in individual phases, which are most often defined as rewards or penalties [10].

The paper deals only with costs, while performance and quality are defined separately. Some authors [7] place the cost outsourcing function as set together with others, as in:

$$O_{pick,dely} = f\left(C_{pick,dely}, Q_{pick,dely}, P_{pick,dely}\right) \quad (1)$$

Where:

- $O_{pick,dely}$ - is the outsourcing for the first and last technological phase,
- $C_{pick,dely}$ - are the costs arising from the outsourcing of the first and last technological phase,
- $Q_{pick,dely}$ - is the quality of execution of the first and last technological phase,
- $P_{pick,dely}$ - is measuring the performance of the first and last phase.

DEFINING THE CALCULATION MODEL BY THE NUMBER OF STOPS

The outsourcing calculation model in the first and last phase of shipment delivery is based on the number of stopsused by postal / courier companies.

Courier company *A* in a certain defined geographical area *B* in a certain defined period <u>*td*</u> picks up and delivers a certain amount of shipments.

The mode of transport, the required transport capacity, and the challenges at pickup and delivery points are not the same for packages and pallets, and it is necessary to separate shipments that contain such transport units. For this reason, they are defined, separated, and managed separately. It is important for the model to separate the categories of shipments into:

- Shipment parcels (S_{parcel}) and
- Shipment pallets (S_{pal}).

Then separate the stops by shipments categories:

- Stops for shipment parcels ($N_{S,parcel}$) and
- Stops for shipment pallets ($N_{S,pal}$).

A *shipment pallet* is a shipment consisting of at least one pallet. A shipment parcel is a shipment that consists only of a package. A *shipment pallet* can contain both pallets and packages, while a shipment parcel contains only a parcel. According to these settings, it is clear to identify stops for shipments of packages and pallets.

The transport of different categories of shipments (packages and pallets) requires different categories of transport vehicles and their capacities [7]. The category of the vehicle is determined by its maximum load capacity. Each of the defined categories of the vehicle has its specifics due to the costs it carries with it. The costs of vehicle categories consist of [7]: fuel consumption, spare parts costs, costs of individual repairs and maintenance of vehicles, fixed depreciation, registration costs, six-month technical inspections, etc.

It is necessary to introduce a certain coefficient (k), which would identify the category of the vehicle.

To define the category, it is necessary to show the load classes which are shown in Table 1.

The ratio of the coefficients can be displayed:

Table 1: Display of vehicle categories and assigned coefficients

Category	Capacity	Associated coefficient
N1	≤3.5*t*	k_{N1}
N2	>3.5*t*, ≤12*t*	k_{N2}
N3	>12*t*	k_{N3}

$k_{N1} < k_{N2} < k_{N3}$

When making a model, it is necessary to define an initial coefficient equal to 1. The dependence and ratio of individual coefficients from Table 1 can be written [7] as follows:

$k_{N2} = k_{N1} \cdot 1.6,$

$k_{N3} = k_{N2} \cdot 1.6$

For the calculation of the coefficient, costs of 130 vehicles were taken into account where 70 vehicles were N1 category vehicles, 40 vehicles were N2 and 20 vehicles were N3 category vehicles (spare parts, repairs, tyres, petrol, amortization, etc.). The costs were allocated to the category the vehicle belongs to. This cost analysis has shown that the N2 category requires 1,6 greater costs than the N1 category. N3 has 1,6 greater costs when compared to N2. The increased coefficient per category is justified by the differences in the costs per vehicle category.

Postal company *A* in a certain area *B* in the period *td*, organized the first and last technological phase with *n* routes and *j* vehicle category ($j = 1,2,3,4,5$), where each route had a certain number of stops (*N*) as shown in Table 2.

Table 2: Tabular display of the number of stops per route

Route (r)	Capacity	Associated coefficient	Number of stops on the route for shipments parcel	Number of stops on the route for shipments pallet
r_1	j_{r_1}	$k_{j_{r_1}}$	$N_{S,\ parcel,\ r_1}$	$N_{S,\ pal,\ r_1}$
r_2	j_{r_2}	$k_{j_{r_2}}$	$N_{S,\ parcel,\ r_2}$	$N_{S,\ pal,\ r_2}$
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
r_n	j_{r_n}	$k_{j_{r_n}}$	$N_{S,\ parcel,\ r_n}$	$N_{S,\ pal,\ r_n}$

After defining and displaying the number of stops, it is necessary to introduce price tags for individual stop categories which multiply the number of stops in the pickup and delivery for individual categories, as follows:

$s_{s,\ parcel}$ - individual price for each stop in the first and last phase of shipments parcels,

$s_{s,\ pal}$ - individual price for each stop in the first and last phase of shipments pallets,

In the case that a company exclusively performs pickup and delivery of packages, it is not necessary to separate the categories of stops.

The cost defined by the model for picking up and delivering shipments for geographical area *B* and period *td* on route *1* (r_1) can now be calculated

$$W_{B,td,r_1} = k_{j_{r1}} \cdot (N_{S,parcel,r1} \cdot s_{S,parcel} + N_{S,pal,r1} \cdot s_{S,pal}) \qquad (2)$$

Where:

- W_{B,td,r_1} - is the calculated cost per model for route 1(r_1) for geographical area *B* and period *td*,
- $k_{j_{r_1}}$ is the defined coefficient for the vehicle for route 1(r_1),
- $N_{S,\ parcel,\ r_1}$ - is a total number of stops for shipments parcel on route 1(r_1),
- $S_{S,\ parcel}$ - is the individual price for each stop in the first and last technological phases for parcel shipments.

$$W_{B,td,r_1} = k_{j_{r1}} \cdot (N_{S,parcel,r1} \cdot s_{S,parcel} + N_{S,pal,r1} \cdot s_{S,pal})$$

- $N_{S,\ pal,\ r_1}$ is a total number of stops for shipments pallet

$$W_{B,td,r_2} = k_{j_{r2}} \cdot (N_{S,parcel,r2} \cdot s_{S,parcel} + N_{S,pal,r2} \cdot s_{S,pal})$$

on route 1(r_1)

$$W_{B,td,r_n} = k_{j_{rn}} \cdot (N_{S,parcel,rn} \cdot s_{S,parcel} + N_{S,pal,rn} \cdot s_{S,pal})$$

- $S_{S,\ pal}$ - is the individual price for each stop in the first and last technological phases for pallet shipments.

$$W_{B,td} = \sum_{k=1}^{n} W_{B,td,r_n}$$

Below are the defined costs according to the outsourcing model for *n* routes for geographical area *B* in period *td*:

For a route r_1 the cost can be expressed as follows:

For a route r_2: (2)

For a route r_n:

The sum of individual costs per route is the total cost of outsourcing for the selected area and the defined time frame, so it can be recorded:

Keeping records of the number of stops on individual routes can be done in several ways:

- manually, i.e. that the driver writes down how many stops there are during the route,
- by combining the handwritten notes with the system used for dispatching, comparing data,
- by using an automated system, which uses GPS and vehicle stop recording with a dispatching system that assigns consignment to routes and connects several shipments to one address or stops.

The most reliable system is an automated system, where certain advanced systems for managing first and last technological phase operations are based on geographic information systems [11], [12], [13], [14]. By combining these systems and automating the exchange of information, it is possible to control the number of stops and the movement of vehicles, which directly affects costs.

Example of the model application

The courier company covers the territory of Bosnia and Herzegovina. Data from January 2020 were used for the calculation, for a small geographical area of 5 routes covered from the postal center located in the city of Bihac.

Company *A*, which deals with courier business in Bosnia and Herzegovina, is in area B_1 in a period of td = 30 days, collected and delivered a certain amount of shipments on 5 routes with 5 vehicles, 3 vehicles are N_1 category while two are N_2 category vehicles.

Table 3: Routes and data on the number of stops and vehicle categories

Route (r)	Capacity	Associated coefficient	Number of stops on the route for shipments parcel	Number of stops on the route for shipments pallet
r_1	N_1	$k_{N_{1r1}}$	796	21
r_2	N_1	$k_{N_{1r2}}$	416	130
r_3	N_1	$k_{N_{1r3}}$	381	145
r_4	N_1	$k_{N_{1r4}}$	811	14
r_5	N_1	$k_{N_{1r5}}$	738	25

Table 3 lists routes where each route had a certain number of stops for shipment parcels ($N_{S,\ parcel}$) and a certain number of stops for shipment pallets ($N_{S,\ pal}$).

The defined price per stop is:

- $S_{S,\ parcel}$ = 4 BAM and
- $S_{S,\ pal}$ = 9 BAM

By including the data from Table 3 in formula (2) we get the costs per route as follows:

For a route r_1:

$$W_{B_1,td,r_1} = k_{j_{r1}} \cdot (N_{S,parcel,r1} \cdot s_{S,parcel} + N_{S,pal,r1} \cdot s_{S,pal}) = \\ = 1 \cdot (796 \cdot 4 + 21 \cdot 9) = 3,373BAM$$

For a route r_2:

$$W_{B_1,td,r_2} = k_{j_{r2}} \cdot (N_{S,parcel,r2} \cdot s_{S,parcel} + N_{S,pal,r2} \cdot s_{S,pal}) = \\ = 1,6 \cdot (416 \cdot 4 + 130 \cdot 9) = 4,534BAM$$

For a route r_3:

$$W_{B_1,td,r_3} = k_{j_{r3}} \cdot (N_{S,parcel,r3} \cdot s_{S,parcel} + N_{S,pal,r3} \cdot s_{S,pal}) = \\ = 1,6 \cdot (381 \cdot 4 + 145 \cdot 9) = 4,526BAM$$

For a route r_4:

$$W_{B_1,td,r_4} = k_{j_{r4}} \cdot (N_{S,parcel,r_4} \cdot s_{S,parcel} + N_{S,pal,r_4} \cdot s_{S,pal}) = \\ = 1 \cdot (818 \cdot 4 + 14 \cdot 9) = 3,370BAM$$

For a route r_5:

$$W_{B_1,td,r_5} = k_{j_{r5}} \cdot (N_{S,parcel,r_5} \cdot s_{S,parcel} + N_{S,pal,r_5} \cdot s_{S,pal}) = \\ = 1 \cdot (738 \cdot 4 + 25 \cdot 9) = 3,177BAM$$

After calculating the costs for individual routes, using formula (3) we get the total cost for the defined area and time frame of *30 days*:

$$W_{B_1,td} = \sum_{1}^{5} \left(W_{B_1,td,r_1} + W_{B_1,td,r_2} + W_{B_1,td,r_3} + W_{B_1,td,r_4} + W_{B_1,td,r_5} \right) = \\ = 3,373 + 4,534 + 4,526 + 3,370 + 3,177 = \\ = 18,980BAM$$

The calculated cost according to the proposed model for the observed area and time frame of *30 days* is 18,980 BAM.

The model may set certain limits on the number of packages or pallets that can be picked up or delivered at one stop. In that case, it would be necessary to define the coli factor per stop. This would mean that if a larger quantity of packages or pallets is picked up or delivered at one stop, such a stop can be considered as multiple stops.

CONCLUSION

In the present paper, a model for outsourcing services in courier companies in the first and last technological phases has been proposed. To calculate costs, the model uses the number of stops of package shipments and pallet shipments. The model takes into account each route and the specific transport capacities used and takes into account the different types of shipments transported through the network of courier companies. Using the proposed model, the example shows that the costs in the first and the last technological phases depend on the rates of individual vehicles. The authors suggest further research on how to measure the number of stops on each route.

REFERENCES

1. Ko, S. Y., Cho, S. W. and Lee, C. (2018) 'Pricing and Collaboration in Last Mile Delivery Services', Sustainability, 10(12), pp. 1–20. doi: 10.3390/su10124560.
2. Tiwapat, N., Pomsing, C. and Jomthong, P. (2018) 'Last Mile Delivery: Modes, Efficiencies, Sustainability, and Trends', in 2018 3rd IEEE International Conference on Intelligent Transportation Engineering, ICITE 2018, pp. 313–317. doi: 10.1109/ICITE.2018.8492585.
3. Duan, H. et al.(2019) 'Post-consumer packaging waste from express delivery in China', Resources, Conservation and Recycling. Elsevier, 144(January), pp. 137–143. doi: 10.1016/j.resconrec.2019.01.037.
4. Ding, Z. (2014) Evaluating Different Last Mile Logistics Solutions. University of Gävle, Faculty ofEngineering and Sustainable Development. Available at: http://www.diva-portal.org/smash/get/diva2:763544/FULLTEXT01.pdf.
5. Tibor, K. (2006) 'Outsourcing decision support: a survey of benefits, risks, and decision factors', Supply Chain Management: An International Journal. Edited by I. T. Oya. Emerald Group Publishing Limited, 11(6), pp. 467–482. doi: 10.1108/13598540610703864.

6. Sahay, B. S. and Mohan, R. (2006) ‘3PL practices: An Indian perspective’, International Journal of Physical Distribution &Logistics Management, 36(9), pp. 666–689. doi: 10.1108/09600030610710845.
7. Kosovac, A., Muharemović, E. and Trubint, N. (2020) ‘A Cost Calculation Model for Outsourcing in Parcel Pick-up and Delivery by Commercial Postal Services Operators’, TEM JOURNAL-TECHNOLOGY EDUCATION MANAGEMENT INFORMATICS. NOVI PAZAR, ASSOC INFORMATION COMMUNICATION TECHNOLOGY EDUCATION & SCIENCE, 9(1), pp. 216–220. doi: 10.18421/TEM91-30.
8. Boyer, K. K., Prud’homme, A. M. and Chung, W. (2009) ‘THE LAST MILE CHALLENGE: EVALUATING THE EFFECTS OF CUSTOMER DENSITY AND DELIVERY WINDOW PATTERNS’, Journal of Business Logistics, 30(1), pp. 185–201. doi: 10.1002/j.2158-1592.2009.tb00104.x.
9. Kin, B. et al.(2018) ‘Modelling alternative distribution set-ups for fragmented last mile transport: Towards more efficient and sustainable urban freight transport’, Case Studies on TransportPolicy. World Conference on Transport Research Society, 6(1), pp. 125–132. doi: 10.1016/j.cstp.2017.11.009.
10. Thakur, R. K. (2016) Assessment Model for Outsourced Pick-Up and Delivery Operations. MIT Global SCALE Network. Available at: https://www.misi.edu.my/3.0/media-files/2015/12/Assessment-Model-for-Outsourced-Pick-Up-and-Delivery-Operations.pdf.
11. Deljanin, A., Čolaković, A. and Muharemović, E. (2014) ‘Rationalization of Transport of Postal Shipment using GPS/RFID Technologies in Bosnia and Herzegovina’, Suvremeni Promet -Modern Traffic, 34(1–2), pp. 26–31.
12. Deljanin, A., Kosovac, A. and Muharemović, E. (2017) ‘Use of ITS System as a Track&Trace in Express Delivery in Bosnia and Herzegovina’, Suvremeni Promet -Modern Traffic, 37(1–2), pp. 30–35.
13. Jung, H., Lee, K. and Chun, W. (2006) ‘Integration of GIS, GPS, and optimization technologies for the effective control of parcel delivery service’, Computers and Industrial Engineering. Elsevier Ltd, 51(1), pp. 154–162. doi: 10.1016/j.cie.2006.07.007.
14. Čaušević, S. et al.(2018) ‘Potentials and advantages of applying geographic information systems in various fields of traffic engineering’, in Road and Rail Infrastructure V. University of Zagreb Faculty of Civil Engineering, pp. 1285–1290. doi: 10.5592/co/cetra.2018.735

Paper submitted: 17.09.2020.
Paper accepted: 24.01.2021.