A Proposed Outsourcing Model for Pick-up and Delivery Processes

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Abstract

In the last few years, we have been active participants in globalization and the rapid growth of online commerce. This trend directly impacts logistics, postal, and courier companies. Challenges are visible in the growth and development of these companies, as well as quality of task execution and the ability to adapt to market conditions. With the impact of the SARS-COV-19 virus on the market, and due to locks during the pandemic, shoppers were forced to buy products online. This effect accelerated the trend of purchases via e-commerce, which increased the number of parcels in the technological phases of pick-up and delivery. These companies are the bearers of the first and last technological phase of shipment transport. Due to the increase in the number of shipments, postal and logistics companies are under great pressure. This is because of certain restrictions introduced during the pandemic, but also because of costs, especially fixed costs in the first and last phase of transport. This paper proposes an outsourcing model for the pick-up and delivery to convert fixed costs into variable ones.

Keywords: model, delivery, pick up, outsourcing, shipment, costs

1 Introduction

The accelerated pace of digital innovation, the rapid increase in data collection and transmission, the emergence of platforms that facilitate innovation, as well as the increased participation of online users have resulted in the growth of the digital economy. The growth trend of the digital economy was also accelerated by the covid 19 pandemic because there were a large number of lockdowns, so users were forced to buy products through e-commerce [1]. The World Health Organization, in its update of April 4, 2022, shows 489,779,062 confirmed cases of infection and 6,152,095 confirmed deaths [2].

According to the report [3], e-commerce accounts for 10-15% of total retail sales in European Union countries. In 2020, 71% of the EU population bought through e-commerce, 66%, in 2019, and 64% in 2018 [3]. This report states that all 27 EU member states experienced an increase in traffic in the B2C segment of e-commerce during the covid-19 pandemic. Through the mass use of smartphones, and widespread access to the Internet, mobile online shipping is becoming increasingly present.

Increased purchases through e-commerce have a direct impact on pick-up and delivery companies, resulting in increased number of shipments. These challenges require postal and logistics companies to quickly adapt their network, services, information systems, but also business priorities.

Postal and logistics companies are also under pressure, because of the price of services, as well as the costs of new shipments produce. New shipments require the engagement of additional capacity and infrastructure elements [4]. The increase in the number of shipments shows that transport prices do not grow in proportion to the new volume, while costs grow faster than revenue [5]. Special attention is required for research that predicts a twofold increase in deliveries in developed markets [6].

Under the pressure of increasing costs in the last phase of delivery, the companies try various ways to reduce costs and keep the business at a certain level. A special problem with postal and logistics companies in the first and last phase is fixed costs, which grow rapidly with increasing volume. The main fixed costs in the pick-up and delivery are fixed salaries of employees (drivers) and depreciation of transport vehicles in collection and delivery. According to research [7], 57% of the total operating costs of postal and courier companies arise from the first and last technological phase. The last mile of delivery is the most demanding and least predictable process in the postal and logistics system [8].

Shipments generated through e-commerce are mostly delivered to inner-city zones, which are especially challenging in the delivery. Time constraints on vehicle movement, the noise produced by transport vehicles, environmental protection, infrastructure constraints, but also other factors play an important role in the organization of the delivery.

The biggest economic advantage that researchers point out for outsourcing is that it enables the conversion of fixed costs into variable ones and the reduction of capital costs [9]. In addition to cost advantages, outsourcing allows companies to:

- improve quality and transport capacities,
- increase profitability and productivity,
- reduce costs and risks of innovation,
- transfer of the risk of transport of shipments, etc.

Research conducted on the use of outsourcing [9], based on the results after outsourcing, shows that companies have managed to reduce costs by about 9%. At the same time, the companies managed to improve the quality and capacity of services by about 15% [4], [9].

Research based on outsourcing services in the field of the first and last delivery phase is quite scarce. Papers dealing with this issue are given below.

The model based on parameters: average time per stop, the distance between stops, the average distance from the warehouses to the first stop, and average speed of movement, are processed by the authors in their papers [10], [11].

Paper [12] deals with the model of estimating pick-up and delivery operations in outsourcing conditions, for monitoring the performance and quality of task execution. This paper proposes monitoring certain performance and quality of execution of external company activities.

The outsourcing model through which the calculation of costs is defined based on the number of stops in the pick-up and delivery of shipments is shown in [13]. The authors are not based on the quality of task execution, because that part is separate from the calculation of costs in the first and last phases.

One of the most commonly used models for calculating outsourcing services, in the first and last phase, is the model based on mileage [4].

When creating a contract for outsourcing services, the costs of collection and delivery are separate from performance and quality. Performance and quality can define through SLA (service-level agreement) as rewards or penalties. For this reason, the paper deals only with the costing model, while the quality and performance of the first and last phases can be observed in the overall outsourcing contract. As shown in papers [13], [4]:

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

Where:

- $O_{pick,dely}$ - Outsourcing contract for the pick-up and delivery phase,
- $C_{pick,dely}$ - Costs in the pick-up and delivery phase,
- $Q_{pick,dely}$ - Quality of execution of activities,
- $P_{pick,dely}$ - Performance in the pick-up and delivery phase.

This paper aims to propose an outsourcing model for activities in the pick-up and delivery phases of postal and logistics companies. The proposed model is based on the number of shipments to be picked up and delivered by postal and logistics companies.

2 Research Methodology

The methodology of the proposed research was conducted in two phases. In the first phase, the input parameters were defined and a mathematical model for outsourcing was set. In the second phase of the research, a concrete example of using the model is given.

2.1 Defining a model

Postal company *C*, in a certain area of service *G*, in a certain period *t*, picks-up and delivers a certain number of shipments. For this model, it is necessary to distinguish the shipments:

- shipments that contain only packages are called parcel shipments (S_{parcel}), and
- shipments that contain at least one pallet are called pallet shipments (S_{palet}).

This difference is necessary due to the difference in the occupancy of transport capacities, the manner of their manipulation, and the challenges at the points of collection and delivery.

For further understanding and definition, it is necessary to separate the categories of shipments, as well as the place of pick-up and delivery:

- parcel shipments in the pick-up ($S_{parcel,pick}$),
- pallet shipments in the pick-up ($S_{palet,pick}$),
- parcel shipments in the delivery ($S_{parcel,dely}$),
- pallet shipments in the delivery ($S_{palet,dely}$),

Pick-up and delivery of different categories of shipments request different categories of transport capacities (vehicles) [4]. The category of the vehicle is determined by its load capacity. Different categories of vehicles produce different costs. According to the paper [13], a coefficient (k) was introduced which shows the category of vehicles in the calculation of outsourcing costs. The definition of vehicle categories is given in Table 1, and according to papers [13], [4].

Table 1. Defining vehicle categories and coefficients [13], [4].

Vehicle categories	Capacity	Vehicle category coefficient
N1	$\leq 3.5t$	k_{N1}
N2	$> 3.5t \leq 12t$	k_{N2}
N3	$> 12t$	k_{N3}

The ratio of the coefficients can be displayed: $k_{N1} < k_{N2} < k_{N3}$.

To define the model, it is necessary to define an initial coefficient k_{N1} equal to 1. The ratio of other defined coefficient costs can be written [13], [4]:

$$k_{N2} = k_{N1} \cdot 1.6, \qquad (2)$$
$$k_{N3} = k_{N2} \cdot 1.6 \qquad (3)$$

The increase in the coefficients for the N2 and N3 categories of vehicles results from the difference in costs by categories such as fuel, depreciation, etc costs.

Company C covers the geographical area G, for a certain time zone t with n routes ($r = r_1, r_2, r_3 \dots r_n$) and i vehicle category ($i=1,2,3...$). Each route is covered by a specific category of vehicle that picks up and delivers a certain number of different categories of shipments.

To calculate the total number of parcel shipments for the geographical area G and period t in pick-up and delivery, the following applies:

$$T_{parcel,r_n} = T_{parcel,pick,r_n} + T_{parcel,dely,r_n} \qquad (4)$$

Where:

- T_{parcel,r_n} – the total number of parcel shipments on the route n,
- $T_{parcel,pick,r_n}$ – the total number of parcel shipments on the route n in pick-up,
- $T_{parcel,dely,r_n}$ – the total number of parcel shipments on the route n in delivery,

The total number of parcel shipments in the pick-up and delivery is calculated as:

$$T_{parcel,pick,r_n} = \sum S_{parcel,pick,r_n} \qquad (5)$$
$$T_{parcel,dely,r_n} = \sum S_{parcel,dely,r_n} \qquad (6)$$

To calculate the total number of pallet shipments for the geographical area G and period t in pick-up and delivery, the following applies:

$$T_{palet,r_n} = T_{palet,pick,r_n} + T_{palet,dely,r_n} \qquad (7)$$

Where:

- T_{palet,r_n} – the total number of pallet shipments on the route n,
- $T_{palet,pick,r_n}$ – the total number of pallet shipments on the route n in pick-up,
- $T_{palet,dely,r_n}$ – the total number of pallet shipments on the route n in delivery,

The total number of pallet shipments in the pick-up and delivery is calculated as:

$$T_{palet,pick,r_n} = \sum S_{palet,pick,r_n} \qquad (8)$$
$$T_{palet,dely,r_n} = \sum S_{palet,dely,r_n} \qquad (9)$$

Table 2 shows a simple overview of routes, vehicle categories, associated coefficients, and the total number of parcels and pallets shipments.

Table 2. Display of routes in the geographical area *G* and period *t*

Route (r)	Vehicle categories	Vehicle category coefficient	The total number of parcel shipments	The total number of pallet shipments
r_1	i_{r1}	$k_{i_{r1}}$	T_{parcel,r_1}	T_{palet,r_1}
r_2	i_{r2}	$k_{i_{r2}}$	T_{parcel,r_2}	T_{palet,r_2}
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
r_n	i_{r_n}	k_{i_m}	T_{parcel,r_n}	T_{palet,r_n}

After defining different types of shipments and categories of transport trucks, it is necessary to introduce labels for the prices of individual shipment categories:

$P_{S_{parcel,pick}}$ - individual price for each parcel shipment in pick-up,

$P_{S_{parcel,dely}}$ - individual price for each parcel shipment in delivery,

$P_{S_{palet,pick}}$ - individual price for each pallet shipment in pick-up,

$P_{S_{palet,dely}}$ - individual price for each pallet shipment in delivery,

If an individual route is different in relation to other routes, then it is possible to define individual prices only for that route. It is recommended that prices be the same for all routes.

After defining the prices and the number of shipments individually in the pick-up and delivery for the geographical area G and period t, the calculation of costs (C) can be calculated according to the following formulas.

The cost of picking up parcel shipments on the r_n route can be calculated:

$$C_{parcel,pick,r_n} = T_{parcel,pick,r_n} \cdot P_{S_{parcel,pick}} \cdot k_{i_{r_n}} \quad (10)$$

The cost of delivery parcel shipments on the r_n route can be calculated:

$$C_{parcel,dely,r_n} = T_{parcel,dely,r_n} \cdot P_{S_{parcel,dely}} \cdot k_{i_{r_n}} \quad (11)$$

The cost of picking up pallet shipments on the r_n route can be calculated:

$$C_{palet,pick,r_n} = T_{palet,pick,r_n} \cdot P_{S_{palet,pick}} \cdot k_{i_{r_n}} \quad (12)$$

The cost of delivery pallet shipments on the r_n route can be calculated:

$$C_{palet,dely,r_n} = T_{palet,dely,r_n} \cdot P_{S_{palet,dely}} \cdot k_{i_{r_n}} \quad (13)$$

After defining the costs by categories and phases, the cost of pick-up and the cost of delivery on the route r_n, can be calculated as follows:

$$C_{pick,r_n} = C_{parcel,pick,r_n} + C_{palet,pick,r_n} \quad (14)$$

$$C_{dely,r_n} = C_{parcel,dely,r_n} + C_{palet,dely,r_n} \quad (15)$$

Total cost of parcel and pallet shipments in pick-up and delivery on all routes:

$$C = \sum_1^n C_{pick,r_n} + \sum_1^n C_{dely,r_n} \quad (16)$$

2.2 Example of cost calculation using the proposed model

The data used in the example are from a postal company operating in Bosnia and Herzegovina. Data are from November 2021 for the area of northern Bosnia. A postal company picks up and delivers shipments in the geographical area of northern Bosnia (marked as G_1). In a period of $t = 30$ days, the company picked up and delivered shipments on 4 routes with 4 vehicles. Three vehicles are off the N1 category and one vehicle from the N2 category. Table 3 gives the individual data used as an example.

Table 3. Individual data used as an example

Route (r)	Vehicle categories	*Vehicle category coefficient*	The total number of parcel shipments	The total number of pallet shipments
r_1	N_1	$k_{N_{1_{r1}}}$	1125	8
r_2	N_1	$k_{N_{2_{r2}}}$	782	13
r_3	N_2	$k_{N_{2_{r3}}}$	340	95
r_4	N_1	$k_{N_{1_{r4}}}$	1146	6

Defined prices for outsourcing, by categories of shipments and phases:

- $P_{S_{parcel,pick}} = 6\ BAM$
- $P_{S_{parcel,dely}} = 6\ BAM$
- $P_{S_{palet,pick}} = 44\ BAM$
- $P_{S_{palet,dely}} = 44\ BAM$

As we know the quantities of shipments and individual prices, the cost per route can be calculated:

Cost for route r_1:

$C_{pick,r_1} = C_{parcel,pick,r_1} + C_{palet,pick,r_1} = 450 \cdot 6 \cdot 1 + 3 \cdot 44 \cdot 1 = 2{,}845.76$ BAM

$C_{dely,r_1} = C_{parcel,dely,r_1} + C_{palet,dely,r_1} = 675 \cdot 6 \cdot 1 + 5 \cdot 44 \cdot 1 = 4{,}268.64$ BAM

$C_{r_1} = C_{pick,r_1} + C_{dely,r_1} = 7{,}114.41 \; BAM$

Cost for route r_2:

$C_{pick,r_2} = C_{parcel,pick,r_2} + C_{palet,pick,r_2} = 313 \cdot 6 \cdot 1 + 5 \cdot 44 \cdot 1 = 2{,}111.89$ BAM

$C_{dely,r_2} = C_{parcel,dely,r_2} + C_{palet,dely,r_2} = 469 \cdot 6 \cdot 1 + 8 \cdot 44 \cdot 1 = 3{,}167.83$ BAM

$C_{r_2} = C_{pick,r_2} + C_{dely,r_2} = 5{,}279.72 \; BAM$

Cost for route r_3:

$C_{pick,r_3} = C_{parcel,pick,r_3} + C_{palet,pick,r_3} = 136 \cdot 6 \cdot 1.6 + 38 \cdot 44 \cdot 1.6 = 3{,}984.54$ BAM

$C_{dely,r_3} = C_{parcel,dely,r_3} + C_{palet,dely,r_3} = 204 \cdot 6 \cdot 1.6 + 57 \cdot 44 \cdot 1.6 = 5{,}976.81$ BAM

$C_{r_3} = C_{pick,r_3} + C_{dely,r_3} = 9.961{,}34 \; BAM$

Cost for route r_4:

$C_{pick,r_4} = C_{parcel,pick,r_4} + C_{palet,pick,r_4} = 459 \cdot 6 \cdot 1 + 2 \cdot 44 \cdot 1 = 2{,}848.16$ BAM

$C_{dely,r_4} = C_{parcel,dely,r_4} + C_{palet,dely,r_4} = 688 \cdot 6 \cdot 1 + 3 \cdot 44 \cdot 1 = 4{,}272.24$ BAM

$C_{r_3} = C_{pick,r_3} + C_{dely,r_3} = 7{,}120.41 \; BAM$

When individual costs per route are known, it is necessary to summarize all costs according to formula (16). Therefore, the total outsourcing costs for this area and the observed period will be:

$$C = \sum_{1}^{n} C_{pick,r_n} + \sum_{1}^{n} C_{dely,r_n}$$
$$= 2{,}845.76 + 2{,}111.89 + 3{,}984.54$$
$$+ 2{,}848.16 + 4{,}268.64 + 3{,}167.83$$
$$+ 5{,}976.81 + 4{,}272.24$$
$$= 29{,}475.88 \text{ BAM}$$

Total costs according to the proposed model of calculation of costs per shipment, for geographical area G and period $t = 30$ days, is 29,475.88 BAM.

Of course, certain limits can be set through the model in terms of the number of units that can be contained in one shipment, as well as the coli factor per shipment.

3 Conclusion

The paper presents a proposal for a model of outsourcing the first and last technological phase in postal and logistics companies. The proposed model is based on the calculation of the number of shipments in the stages of pick-up and delivery. The model also considers the category of vehicle that performs the task scheduled for pick-up and delivery.

The model deals only with the cost side of outsourcing, while the quality and performance of the planned tasks are specifically defined. The main goal of the model is for the company operating in the first and last phase to optimize fixed costs by converting costs into variable ones. Through the model, it is possible to adjust the cost structure of the first and last phase to the changes and fluctuations of shipments, which occur in postal and logistics companies. These fluctuations are especially pronounced in certain seasons such as winter or summer.

E-commerce also plays an important role in shipment fluctuations, as a channel for product placement and purchases. The directions of further research can be related to detailed research and the definition of the cost coefficient. Also, directions of further research can be the development of an application that will enable the automation of cost calculation through this model.

Competing Interest Statement

The authors declare no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

Data Availability

No additional data or materials were utilized for the research described in the article.

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