Substantiation of the model for forecasting cargo flow of regional post offices

Andrey Reshenkin¹, Natalia Kochkovaya²*, and Irina Usova²

¹Don State Technical University, 1, Gagarina sq., Rostov-on-Don, 344002, Russia
²Institute of Technologies (branch) of Don State Technical University in Volgodonsk, 16, Mira str., Volgodonsk, 347386, Russia

Abstract. The substantiation of the model for forecasting the cargo flows of mail delivery for the regional postal network using statistical data on the results of the operation of post offices and the entire network as a whole is proposed. An algorithm for developing such a model is proposed in order to improve the quality of postal services and reduce the cost of postal transportation across the region.

1 Introduction

The analysis of vehicle work efficiency of regional postal network in which a system of technical and using indicators is carried out does not allowe to see the accurate transp

Nowadays the car transport has a role of base linking constituent in post manufacturing technological chain of the majority regions. For certain reasons the car transport is as a serving chain of post offices. The main task for accurate modern postal items delivery is a study and analysis of post transportation car route network through a definite region.

The substantiation of post cargo transportation model for the postal network with the statistics is carried out. Using the model we have the opportunity to make management decisions to improve post transport efficiency.

The algorithm of such a model design with to aim to increase the quality of post service and decrease the cost of postage is suggested.

Putting the suggested algorithm and forecast models will significantly save money spent on satisfying consumers in the distribution of postal products.

2 Materials and methods

Based on the accepted structure of the regional postal network and the classifications of logistic systems we can conclude that the structural model shown in Figure 1 is a complex hierarchical system consisting of individual logistic elements which belongs to the class of macrologistic systems.

It is important to note that in this system there are vertical and horizontal connections between the elements through which uneven material flows in the form of postal items

* Corresponding author: kochkovaya@mail.ru
circulate. The considered flows are subjected to various logistic operations and functions which are limited by the influences of the external environment [2].

The importance of the influence of external factors on the functioning of the postal network can be assessed using this example. In Soviet times most of the postal items were carried out by rail and since 2005 the movement of postal items within most regions is carried out by various types of road transport. This is due both to the increase in the tariffs for the transportation of mail by rail and the non-observance of the terms of its delivery.

Thus at present road transport plays the role of a basic link in a single technological chain of postal production in most regions of Russia providing material postal flows and acting as a service link for post offices in the macrologistics system of the region.

![Structure scheme of the region postal network](image)

**Fig. 1.** Structure scheme of the region postal network

In this connection the management of regional networks is faced with the need to study the state and movement of postal cargo flows in the postal network primarily on the basis of the accumulated statistical material. In economic theory one of the fields of such research is the development and use of models for forecasting postal cargo flows based on the principles of logistics. It is possible to carry out a more thorough study and analysis of the automobile route network of postal transportation through the territory of a particular region in order to rationalize it or rather optimize it by eliminating parallel transportation and introducing ring routes with the obligatory observance of control delivery dates for postal items.

An analysis of the existing methods of organizing the transport process and the fact that transport in a unified postal technology plays a defining and organizing role allows us to propose the following algorithm for developing a model for forecasting postal traffic in the regional postal network when providing postal services:
From the algorithm presented in Figure 2 it can be seen that the main stage in organizing the process of transporting mail is the analysis and calculation of the cargo flows of mail transported within the regional network.

The next step is to optimize the transport postal routes (routing). At the same time, optimized routes should correspond to postal cargo flows having the shortest transportation distances, ensuring traffic safety and maximum travel speed. At the same time, the type is selected and the optimal number of vehicles is calculated for the transportation of postal items.

Based on the need to save material resources, the transportation of postal items in regional postal networks is carried out only by road.

That’s why it’s possible to single out the initial data for solving the problem: the volume of transported postal cargo (their dimensions, weight, type of packaging, the presence of special postal requirements for their loading and unloading and transportation), transportation distance, the state of the road transport network, technical characteristics and productivity of vehicles, modes of operation of post offices.

It should be noted that the distribution of postal vehicles (brand, carrying capacity, etc.) along the routes is made according to the total volume of cargo traffic in each direction in all types of postal items.

The carried out analysis [3] allows us to conclude that the system of technical and operational indicators is traditionally used to assess the economic efficiency of vehicles which does not allow for the most accurate consideration of transport costs. Taking into account foreign experience based on a logistic approach, many experts recommend the assessment of the transport process be carried out within the framework of a single transport and technological process.

It is important to note that the methodology of the proposed models, in particular the model for forecasting postal cargo flows, is based on the assumption that they can be used to evaluate and be able to make management decisions to improve the efficiency of postal transport. But it is clear that both the result of the postal service and the result of the transport service for the transportation of postal items is the effect of the movement of...
postal products. Therefore the process of transportation of postal items is the main integration element of postal production in the implementation of postal services.

The urgency of solving the problem of studying postal cargo flows in the form of postal items is increasing due to the fact that the development of the economy and the volume of postal items begin to increase gradually.

In this regard the basis is the idea formulated in many works that use the conceptual apparatus of distribution logistics and which is associated with solving the problem of optimizing the transport activities of post offices for the transportation of postal items [4-7].

It is proposed to use models for forecasting cargo flows based on the principles of logistics, which ultimately makes it possible to make management decisions that help reduce the cost of cargo transportation.

It’s obvious that constructing and further using such models is necessary to take into account the peculiarities of postal production which imply a reciprocal effect of the quality of the postal service on the income of post offices and vice versa.

In its turn, such approach is fully consistent with the very idea of modernizing the postal service aimed at ensuring the required quality by increasing the speed of forwarding and delivering postal items.

Returning to the structural model of the regional postal network (Figure 1), it should be noted that material flows in the form of postal items arise in the post office (PO) and their further movement through the chain of production, transport links to the final consumer, constantly increasing in cost begins from this primary source.

At the same time the main functional links in the considered structure are post offices. The main logistic costs are formed according to their work. It clearly confirms the algorithm for the implementation of the procedure for receiving, processing and delivering letters from a client to an addressee (Figure 2). The algorithm is developed on the basis of an analysis of technological processes in postal production.

Fig. 3. Algorithm of implementing the procedure for receiving processing and delivering letters to addressees

It is known that the mechanism of logistics is most effective when it deals with one-way material flows. However there is a two-way movement of postal flows in the regional postal network. So according to the classification given in the postal rules, postal cargo flows leaving the regional postal network are called outgoing flows, and otherwise - incoming flows Therefore we make the following assumptions:

- we accept incoming and outgoing mail flows equal;
- we do not consider the activities of the transit chain of the Federal State Unitary Enterprise Russian Post;
- we consider the movement of material flows for each type of correspondence only within the postal network of the branch of the Federal Postal Service of Rostov Region. We accept the incoming and outgoing flows transported in one direction as the movement of one total flow.
- we accept that considering the movement of the outgoing material flow of postal items to an addressee located outside the region, the sorting center (hub) of the Federal State Unitary Enterprise Russian Post backbone chain plays the role of the recipient of the postal item for the macrologistic system of the network, and when considering the incoming flows of the postal item – «hub» plays the role of the sender. Structurally this assumption has the form shown in Figure 4.

![Fig. 4. Scheme of the flow of postal items of the internal postal system](image)

When these assumptions are fulfilled we are able to change two-way traffic into one-way traffic. In this case we can have an opportunity to use all the available theoretical and estimated potential of logistics. This will eventually allow us to analyze the possibilities of logistic management of the movement of material flows within the regional postal network based on the developed statistical model for forecasting postal cargo flows based on the principles of logistics [8].

Thus it is assumed that material flow management will represent an efficient distribution of the components of material flows in accordance with the conditions of logistics. At the same time it will be possible to bring the postal system into a form that allows for the logisticization of postal cargo flows with the help of the assumptions introduced.

Having considered some ideas about the functional, target and flow structures of the macrologistic system we will briefly consider the logistics operations and functions.

Logistic operations with material flows in the considered logistics system include: loading, unloading of postal items, warehousing, packaging and labeling, formation (disbandment) of shipments and other operations.

Logistic functions with material flows include:
- forwarding service;
- transportation;
- cargo sorting;
- distribution.
Analyzing the activities of the structural divisions of the Federal State Unitary Enterprise Russian Post, we can say that the reserves for improving the profitability of post offices are in the field of optimizing the material flows of postal items and speaking more precisely it is in the field of optimizing the logistic costs associated with them.

The organization of such management in the postal network in Rostov region will reduce the time for the passage of postal items throughout the chain of the branch as well as reduce transportation costs.

For the practical organization of end-to-end management of logistic costs it is necessary to use a logistic approach that involves optimizing the sum of all logistic costs but not the «optimum sum».

The organization of end-to-end management of logistic costs is impossible without organizing and ensuring effective end-to-end movement of material flow in the form of postal items from the sender to the addressee through the postal network by implementing the process of logistics of all links of this network.

It's obvious that the end-to-end management of logistic costs involves the organization and control of the end-to-end movement of postal items. Moreover it is necessary to know its initial state and how it is transformed under the influence of various factors into a consumer product. In addition, as noted by a number of economists, in order to study the process of managing logistics costs in order to control and optimize them it is necessary to know their transformation into value added [9].

In practice, such a change is achieved through targeted impacts on the material flows of postal items of a set of logistic operations which combined into logistics functions, contribute to the movement of postal products in space and time from the sender to the recipient.

Thus, the issue of using and developing logistics in the study of postal production taking into account local geographical and demographic conditions is very urgent for the regional postal network.

The postal market creates objective preconditions for the use of modern logistic technologies for the organization of cargo and goods movement by the transport divisions of the branch. It has a positive effect on the organization and movement of postal cargo flows [10].

For studying the state of the postal traffic of the regional postal network, the quantitative and qualitative state of the postal fleet is of great importance.

Here, the issues related to the optimization and rationalization of the transportation processes of postal products along inter-district and intra-district routes acquire the greatest relevance.

The solution of these issues must be carried out using a statistical model for forecasting postal cargo flows on the principles of logistics for each of the postal routes and for each postal item.

It is known that the profitability of any enterprise is determined simultaneously by income and expenses, which are always inextricably linked, and that the profitability of post offices network largely depends on the efficiency of managing logistic costs, the main share of which is due to transportation costs, the main result of forecasting postal freight traffic should be a reduction in transport costs or their main component and it’s the cost of transportation.

Thus we can say that the developed model for forecasting postal cargo flows based on the principles of logistics should ultimately contribute to the effective solution of the following tasks:
- choice of type and brand of vehicle depending on the current traffic;
- determination of rational routes and optimization of the total number of routes;
- integrated planning of transport, storage and production processes.
It is important to note that the use of the model for forecasting postal cargo flows based on the principles of logistics does not exclude the use of other models, the use of which would supplement the results of the research. Moreover, the dominant feature of such models is that their design is based on the process (transportation) of delivery.

Thus, the development of a model for forecasting postal cargo flows is a necessary, but not sufficient, condition for solving the problem of optimizing material internal mail flows in the regional postal network, which is based on the criterion of minimizing the total logistics costs, the main component of which is the cost of transporting various types of postal items. In the future, we propose, based on the results obtained using the structural and forecast model of postal cargo flows, which can be considered as functional, to start building a generalized functional-structural model (FSM), which will more effectively determine the possibility of reducing the cost of transportation and delivery of postal items.

Taking into account the complexity and multicriteria of solving the problem of optimizing and rationalizing the transportation processes of postal products along inter-district and intra-district routes, the process of solving it, using the decomposition method, is conditionally divided into three stages, involving the solution of three blocks of tasks.

The structural content of each stage is presented in Figures 5, 8, and 9, respectively.

The initial step in solving the task is to analyze the main parameters of the postal transportation process (Figure 5) and environmental factors (Figure 6) that affect the amount of cargo traffic based on the collected statistical information.

Postal traffic is affected by the factors shown in Figure 5.

Using the capabilities of the model for forecasting postal cargo transportation in the region, an analysis of their condition is carried out and management decisions are made on their changes.

**Fig. 5. Cargo traffic analysis scheme**

It is important to note that in the study of the quality of postal services not enough attention is paid to the issue of ensuring the preparation of postal items for transportation, an effective solution that reduces the time and cost of delivering postal items to the addressee.
The importance of this logistics operation is obvious when considering the entire logistic chain for the delivery of postal items to the addressee (Figure 7).

After a brief analysis of the process of postal transportation and having understood the sequence of movement of postal items along the logistic chain of delivery of postal items to the addressee, we can begin to develop a forecast model for postal cargo flows based on the principles of logistics.

We note that we are only interested in internal cargo flows (outgoing and incoming) circulating in the regional postal network for the organization of which it is responsible. In this case the use of a statistical model for forecasting postal cargo flows makes it possible to most effectively analyze the main indicators of postal cargo flows and the factors influencing them.

When creating a statistical model for forecasting postal cargo flows, the following conditions must be taken into account:

- a systematic approach to solving the problem under consideration;
- adequacy of the model to the real system, objective accounting of interrelated subsystems;
- flexible multivariants, i.e. coordination of material, financial and information flows;
- continuity of the model implementation process;
- formation and optimization of a model of a real system in interconnection.

In addition, it can be concluded that the developed model should allow analyzing two interrelated characteristics of the process (state and functioning).

The state of cargo flows is characterized by their volume and structure (types of postal items). And the functioning is the movement of cargo flows of postal items in the external environment in the direction of the consumer (addressee) across the territory of the region.

At the same time it is assumed that the tasks of functioning in our case include: the choice of optimal options for organizing transportation postal processes, types and types of transport, production and warehouse processes.

Practice shows that optimization of both the functioning and the state of the cargo flow is the main condition for the effective operation of the model.

Thus the developed model for forecasting postal cargo flows should allow solving many problems related to the organization of the movement of postal cargo.

The next stage is related to the routing of postal traffic, the structural solution of which is shown in Figure 8.
It should be noted that there are quite a few variants for solving the routing problem. But in any case it’s difficult to solve optimally.

It is proposed to create a mathematical model in the form of a statistical model for forecasting postal cargo flows, which makes it possible to evaluate the optimality of routes for cost variations with minor changes in routes.

The development of such a model involves organizing an analysis of the current technical condition of vehicles (the third stage), the scheme of which we present in Figure 9. Otherwise as practice shows the basic principle of logistics is reliability.

The condition of vehicles depends on: brand of vehicles; year of issuance; book value; accrued depreciation since the beginning of working; depreciation rates.

The use of vehicles depends on: brand of vehicles; route of movement and its length; frequency and time of work (days of the week and time of day).

The cost of maintaining vehicles includes: the cost of wages for drivers and accompanying postal items; fuels and lubricants; expenses for the centralized acquisition of
motor vehicles; spare parts, materials; the cost of those repairs and maintenance in third-party organizations; utility bills and electricity costs; land payment; payment for telecommunication services; transport tax; contributions to research and development work.

The vehicle mileage database includes: mileage (total), mileage on postal routes, mileage of cars used for household needs.

Solving the problems of the second and third stages will allow determining the logistics costs necessary to ensure the transportation of real postal traffic circulating in the regional postal network within the required time frame.

Thus the creation of a mathematical model in the form of a forecast model for postal cargo flows will allow not only to evaluate the optimality of routes for cost variations with minor changes in routes, but also to analyze the costs associated with ensuring the functioning of road transport used to transport postal items.

At the same time, it should be taken into account that for the regional postal network the most urgent task is to organize the management of the movement of postal items, which would fully satisfy the needs of the client for the timely delivery of postal products in the required volumes, with minimal total costs for mail.

And it means that a significant increase in cargo turnover is not a main task. The saving of funds spent on satisfying consumers in the distribution of postal products is of great importance.

4 Results and discussion

The creation of a mathematical model in the form of a forecast model for postal cargo flows will allow not only to evaluate the optimality of routes for cost variations with minor changes in routes, but also to analyze the costs associated with ensuring the functioning of road transport used to transport postal items.

At the same time, it should be taken into account that for the regional postal network, at present, the most urgent task is to organize the management of the movement of postal items, which would fully satisfy the needs of the client for the timely delivery of postal products in the required volumes, with minimal total costs for mail.

And it means that a significant increase in freight turnover is not a first-order task. In this regard, for transport, the economy of funds spent on satisfying consumers in the distribution of postal products begins to acquire great importance.

It should be noted that the use of methods of economic and mathematical modeling when creating models that allow analyzing the movement of material flows of postal items and the amount of total logistics costs that arise in this case will make it possible to make management decisions that help reduce the cost of providing postal services by optimizing logistic costs and ultimately contribute to the transformation of existing regional postal networks to the form of so-called "logically organized systems" [11], the functioning of which would ensure the performance of postal services with the required quality and minimal total costs.

References


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