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Jasmina Bunevska, Dipl. Ing.
Dr. Sc. Ivo Dukoski
University "Sv. K. Ohridski"
in Bitola
Faculty of Technical Sciences
Department of Traffic and
Transport
Bitola

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A MATHEMATICAL MODEL FOR ESTABLISHING THE QUANTITY OF DELIVERED GOODS IN THE MICROLOGISTICAL DISTRIBUTIVE SYSTEM: CASE STUDY

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1 Introduction

Towns in Macedonia face deferent transportation problems, as a result of nonexistant local and national strategy for defining the goals, development directions, and criteria for evaluating of the urbane transportation.

Mainly, the problems are a result of the concentration of a large number of different functions on limited space and the inherited road infrastructure.

Namely, the urban goods transportation is carrier of many positive and negative effects. So, it is completely clear that an efficient micro-logistical distribution system is an imperative for successful solving of the transportation problems and securing of fast delivery of goods, services and information in the urban areas.

How ever problematic this "operative arena" is it is necessary to be started with the development of a planning and managing strategy, which will integrate the cargo transportation in the local and the regional planning process, step by step.

As a first step in this ambitious duty that should give a clear view of the situation at the moment, and the one that we wish for the future, is the analysis of the quantity of the delivered goods in the defined micro-logistical system. Namely that is the purpose of this work.

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2 Defining of the Micro-Logistical Distributive System: Narrow Central Area of Town of Bitola (NCAB)

If the micro logistical system is oriented toward the market and the end user, or toward the neccesities for delivering of the goodsin neccesary quantities, time and place with minimal logistical expences,[2] while the distribution means spreading of the goods by the quantity, time and place, then, it is clear that the

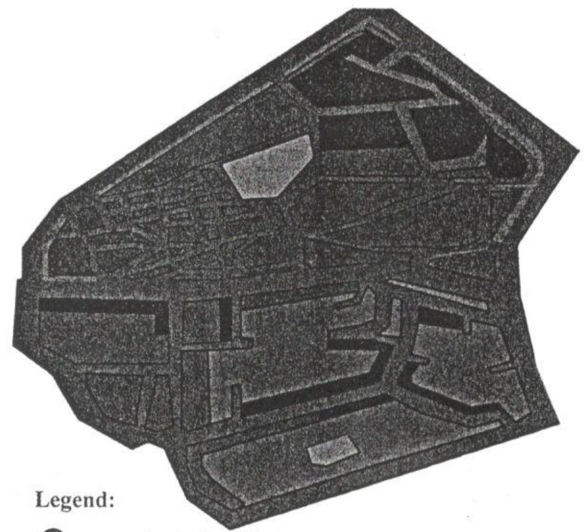

Fig. 1. Land use in the central core of town of Bitola
Source: The authors

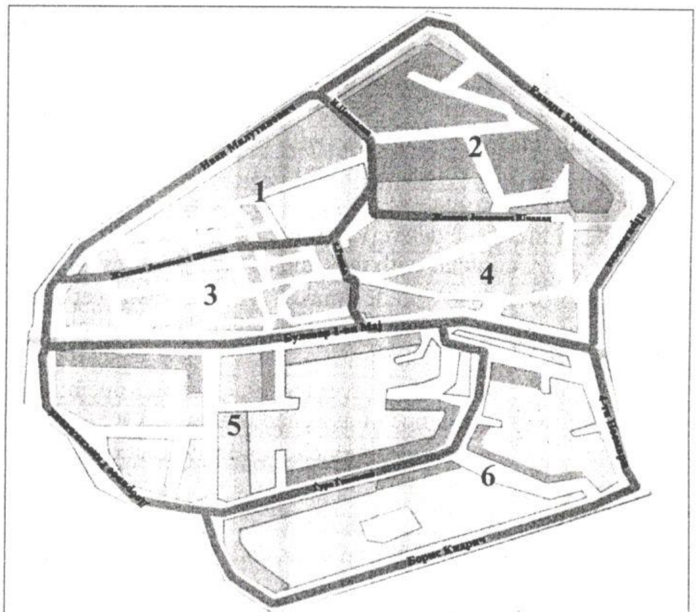

Fig. 2. Traffic roads that define the zones in the central core of town of Bitola
Source: The authors

central city core and the goods delivery to the selling points in it, can be seen as a micro logistical distribution system.

2.1 Area, Land Assignment and Characteristics of the Traffic Network in NCAB

According to the new territorial distribution, NCAB has area of 30 ha [4]. The land assignment is a synthesis of a large number of activities or a developed urbane complex (figure 1). The traffic network is quite specific and formed as a result of the inherited town structure in the central part. It is characterized with non-regular, winding form and geometric profile which is not dimensioned for the modern necessities in the town. For detailed analysis, six zones are defined (z=1,….,6), shown on the next picture with the traffic roads that define the NCAB, four of which are magistral *(Ivan Milutinovic, Prilepska, Dobrivoe Radosavljevic, 4-th of November)* and two collective *(Edvard Kardelj, Boris Kidric), (figure 2).*

3 Analysis of the Type and the Quantity of Goods in the Micro Logistical Distribution System: NCAB

In the introduction was already stated that for the integration of the cargo transportation in the local and regional planning process, in a step by step manner, it is necessary to analyse the real system, in this case the micro logistical distribution system, the NCAB.

Analysis of the NCAB, the micro logistical distribution system, was made and successfully realized through questioning of the people in charge of 200 distribution points during May and June 2005.

Collected and analyzed, this data provided large number of information, but for the needs of this work we will present only those that relate to the type and the quantity of goods, taken as a entering parameters in the mathematical model for calculating the overall quantity of goods that daily and yearly is being brought to the NCAB.

The questionnaire involved seven segments that included data for:

1. Selling place (name, location, category by the type of goods, (...),).
2. Quantity of delivered goods (with one trip, collectively during the day, by zones, daily and yearly, number of trips for distributing the quantity, evennes of the deliveries, (...),).
3. Time frame of the deliveries (if the people receiving the deliveries are contend with the time of the deliveries, (...),).
4. Type of delivery vehicle (make, type, carrying capacity, also information about the vehicle that takes the returned goods, (...),).
5. Unloading and loading (average time for the operations, way of work, existence of assigned points, (...),)
6. Access for the delivery vehicles and information for the parking
7. Synchronization of the deliveries

For the simplification of the analysis and proper processing of the data collected, and to create a model to establish the quantity of the goods delivered daily and yearly, as for the latter connecting of the data in a related data base, we have chosen the Microsoft EXCEL packet.

3.1 Categorization of the Types of Goods in NCAB

Field analysis showed the existence of minor number of specialized points, contrary to the combination of several types of goods in one selling place.

So, as a result of the field situation, 22 categories of goods are analyzed: food products, meat, fish, pharmaceutical products, close, shoes and leather products, cosmetics, toys, books and paper, agricultural chemicals, flowers, agricultural mechanization, household appliances, paints, varnish, rubber and plastics, iron, syntelon and rugs, sanitation, bikes, cars, furniture.

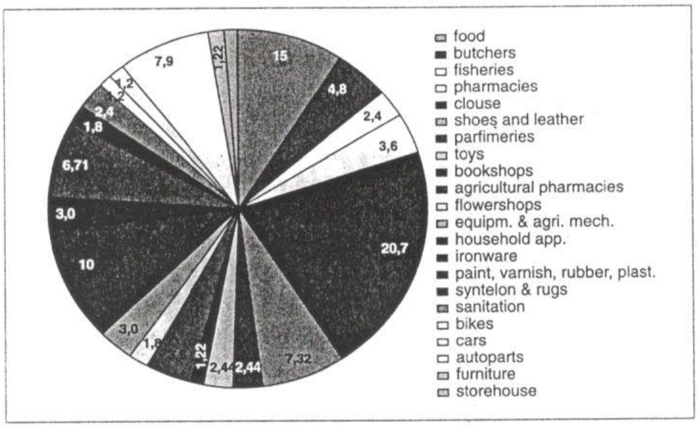

Fig. 3. Categories of goods in NCAB

Source: The authors

4 Methodology and Mathematical Model for Identifying of the Quantity of the Delivered Goods in NCAB

The methodology is presented through three following steps, by making a minimal simplification to eliminate the possible information lack.

The simplification represents finding and introducing of parameter that shows the average quantity of the delivered goods by types, in one point, daily and yearly.

4.1 Mathematical Model for Identifying of the Total Quantity of the Delivered Goods in NCAB

The mathematical model is created in Excel, based on the defined methodology.

1. The average quantity of delivered goods by types in one point, daily and yearly, is being calculated with the following equations:

$$q\,i,d^{pr} = \frac{Qi,d^{vk}}{N_i} \tag{1.1}$$

$$q\,i,g^{pr} = \frac{Qi,g^{vk}}{N_i} \tag{1.2}$$

where:

Qi,d^{vk} – total quantity of delivered goods by types in NCAB daily

Qi,g^{vk} – total quantity of delivered goods by types in NCAB yearly

N_i – total number of points by types in NCAB

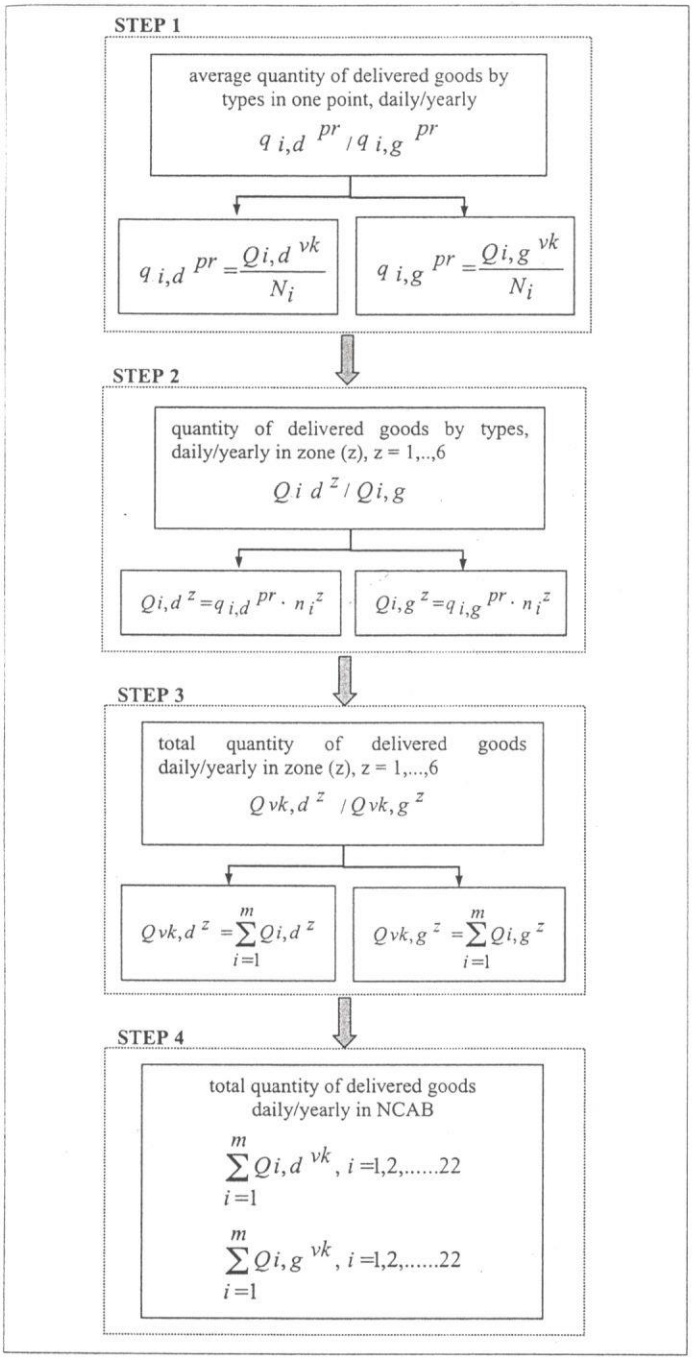

Fig. 4. Methodology for finding the quantity of the delivered goods in NCAB
Source: The authors

2. The quantity of delivered goods by types daily and yearly in each of the six zones, is being calculated with the following equations:

$$Qi,d^{z} = qi,d^{pr} \cdot n_i^{z} \tag{2.1}$$

$$Qi,d^{z} = qi,g^{pr} \cdot n_i^{z} \tag{2.2}$$

where:

qi,d^{pr} – average quantity of delivered goods by types in one point daily

qi,g^{pr} – average quantity of delivered goods by types in one point yearly

$i = 1,\ldots,22$ – types of goods

n_i^{z} – number of selling places in zone (z), z = 1,...,6

3. Total quantity of delivered goods daily and yearly in each of the six zones, is being calculated with the following equations:

$$Qvk,d^{z} = \sum_{i=1}^{m} Qi,d^{z} \tag{3.1}$$

$$Qvk,g^{z} = \sum_{i=1}^{m} Qi,g^{z} \tag{3.2}$$

where:

Qi,d^{z} – total quantity of delivered goods by types, daily in zone (z), z = 1,...,6

Qi,g^{z} – total quantity of delivered goods by types, yearly in zone (z), z = 1,...,6

$z = 1,\ldots6$ – number of defined zones in NCAB

$i = 1,\ldots22$ – types of goods

4. Total quantity of delivered goods in NCAB, daily and yearly

$$\sum_{i=1}^{m} Qi,d^{vk}, i = 1,2,\ldots22 \tag{4.1}$$

$$\sum_{i=1}^{m} Qi,g^{vk}, i = 1,2,\ldots22 \tag{4.2}$$

5 Results of the Analysis of the Micro Logistical System NCAB

Results, or the quantity of delivered goods in NCAB, averagely, by zones, by types, daily, yearly and totally, are in detail presented in the next tables, (table 1, table 2, and table 3).

Input parameters in the mathematical model

Table 1.

number of delivery places totally (N_i) and by zones (n_i^z)								*quantity of goods by types*			
								total (t)		*average (t)*	
		ZONE						*d.*	*y.*	*d.*	*y.*
	N_i	*1*	*2*	*3*	*4*	*5*	*6*	$Q_{i,d}^{vk}$	$Q_{i,g}^{vk}$	$q_{i,d}^{pr}$	$q_{i,g}^{pr}$
1	**15**	0	2	3	4	3	3	153.0	49068.2	10.20	3271.22
2	**8**	1	1	1	4	0	1	1.5	96.72	0.18	12.09
3	**4**	0	0	2	2	0	0	0.7	101.52	0.16	25.38
4	**6**	1	1	2	1	0	1	0.2	48.624	0.04	8.10
5	**34**	7	1	16	7	3	0	3.4	223.02	0.10	6.56
6	**12**	2	0	2	2	6	0	1.9	163.83	0.16	13.65
7	**4**	1	0	3	0	0	0	0.3	19.92	0.07	4.98
8	**4**	0	1	2	0	1	0	0.6	19.92	0.14	4.98
9	**2**	0	0	2	0	0	0	78.0	10944	39.00	5472.00
10	**6**	0	2	0	4	0	0	1.8	181.2	0.30	30.20
11	**3**	1	0	1	1	0	0	1.0	77.52	0.33	25.84
12	**5**	1	1	0	2	0	1	9.5	936.72	1.90	187.34
13	**17**	2	0	8	4	2	1	10.3	1143.1	0.61	67.24
14	**5**	1	0	4	0	0	0	1.1	53.52	0.22	10.70
15	**11**	0	1	3	2	3	2	5.9	293.04	0.53	26.64
16	**3**	1	0	1	1	0	0	12.5	744.72	4.17	248.24
17	**4**	2	1	1	0	0	0	15.5	2424.7	3.88	606.18
18	**2**	0	0	0	2	0	0	4.0	264	2.00	132.00
19	**2**	0	2	0	0	0	0	7.0	336	3.50	168.00
20	**13**	1	1	1	5	2	3	6.7	545.04	0.51	41.93
21	**2**	0	0	1	0	1	0	18.0	864	9.00	432.00
22	**2**	0	0	1	0	0	1	395.0	91920	197.50	45960

Source: Data from the questionnaires, processed by the authors

SUMMARY

Jasmina Bunevska
Ivo Dukoski

A Mathematical Model for Establishing the Quantity of Delivered Goods in the Micrologistical Distributive System: Case Study

This work is one segment of the micro-logistical distributive system in the central historical core of the town of Bitola, realized in May-June 2005. Namely, this analysis gives an overview of different types of goods, yearly load of the area by zones and in total, used vehicles and approach, delivery time frame, the quality of the load-unload manipulations, etc. In this paper a mathematical model for the calculating of delivered quantities by zones, daily and yearly, is presented.

Key words: micro-logistical distributive system, mathematical model

SAŽETAK

Jasmina Bunevska
Ivo Dukoski

Matematički model za određivanje količine isporučene robe u mikrologističkom distributivnom sustavu: studija slučaja

Ovaj je rad dio mikrologističkog distributivnog sustava u središnjoj, povijesnoj jezgri grada Bitole, proveden u svibnju i lipnju 2005. Naime, ova analiza daje pregled različitih vrsta roba, godišnjeg opterećenja područja po zonama i ukupno, korištenih vozila i pristupa, vremena isporuke, kvalitete utovara i istovara itd. Predstavljen je matematički model za izračun isporučenih količina po zonama na dnevnoj i godišnjoj osnovi.

Ključne riječi: mikrologistički distributivni sustav, matematički model