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Calculation of shopping probability by the Huff model in selected retail stores of Kosice (Slovak Republic)

Abstract. The main objective of this article is to apply the theoretical Huff model to specific large-scale sales in the second largest city of the Slovak Republic - Kosice. This theoretical model was applied in relation to the shopping probability of five selected large-scale retail stores, two shopping centres and three hypermarkets found in 22 urban areas of Kosice in the year 2015. Based on the analysis of the results, it is necessary to emphasise their importance in regard to a survey which will be implemented in all urban areas in the future. The reason for the comparison of our calculations and the results of this empirical research is the lack of social or consumer income differentiation in the model.

Keywords: Retail; Availability; Kosice; Huff Model; Large-scale Retail Stores

JEL Classification: D12; D91; M30

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Розрахунок ймовірності здійснення покупок за моделлю Хаффа в магазинах Кошице (Словацька Республіка)

Анотація. Основною метою статті є застосування теоретичної моделі Хаффа щодо визначення можливості великих продажів у Кошице, другому за величиною місті Словацької Республіки. Запропонована теоретична модель була застосована для визначення ймовірності здійснення покупок у п'яти окремо взятих великих магазинах роздрібною торгівлі, двох торгових центрах і трьох гіпермаркетах, розташованих у 22-х районах м. Кошице в 2015 році. Отримані теоретичні результати матимуть значення в контексті опитування, яке буде проведено в усіх районах міста. Приводом для зіставлення теоретичних розрахунків і практичних результатів зазначеного дослідження стала відсутність відображення соціальної диференціації або різниці доходів споживачів у моделі Хаффа.

Ключові слова: роздрібна торгівля; доступність; Кошице; модель Хаффа; великі магазини.

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Расчет вероятности совершения покупок по модели Хаффа в магазинах Кошице (Словацкая Республика)

Аннотация. Основная цель данной статьи заключается в применении теоретической модели Хаффа относительно возможности осуществления крупных продаж в Кошице, втором по величине городе Словацкой Республики. Предложенная теоретическая модель была применена для определения вероятности совершения покупок в пяти отдельно взятых крупных магазинах розничной торговли, двух торговых центрах и трех гипермаркетах, расположенных в 22-х районах Кошице в 2015 году. Полученные теоретические результаты будут иметь значение для последующего опроса, который будет проведен во всех районах города. Поводом для сравнения теоретических расчетов и практических результатов данного исследования послужило отсутствие отображения социальной дифференциации, а также доходов потребителей в модели Хаффа.

Ключевые слова: розничная торговля; доступность; Кошице; модель Хаффа; крупные магазины.

1. Introduction

The gravity models are considered to be the most commonly used type of spatial models. They were developed based on the analogy with the Newtons law of gravitation (Szczyrba, 2006; Kunc et al., 2013) [1-2]. The most famous gravity model is Reilly's law of retail gravitation (Reilly, 1929 [3]; Reilly, 1931 [4]). On the one hand, this model can distort the reality, as it regards the influence sphere of centres as closed and mutually exclusive. On the other hand, studies have shown the existence of a transitional area in which resi-

dents commute to perform shopping in two or more centres. This model does not take into consideration other aspects that affect the distribution of residents' spending from smaller cities into centres, such as transport links, population density, social and income differentiation of consumers and others. Therefore, there may arise some restrictions from using this model. In urban areas, there are more shopping opportunities, thus increasing choice. In connection with these conditions, it was necessary to adjust the classical form of the two-area model by Huff (Huff, 1962; Huff, 1963; Huff, 1964) [5-7].

Therefore, this model was used to calculate the theoretical probability of customer shopping in five selected large-scale retail stores in Kosice.

2. Brief Literature Review

After 1989, in the context of socio-political change, the Slovak retail industry underwent a difficult transformation process from the central directive management to the market economy (Krasny, 1992; Mitrikova, 2005; Mitrikova, 2008; Mitrikova, 2010; Trembosova, 2012) [8-12]. It was influenced by small and large-scale privatisation as well as by atomisation of the retail network, characterized by the emergence of a large number of individual sales units without any vertical or horizontal cooperation (Trembosova, & Dubcova, 2013) [13]. At the stage of concentration and internationalisation, three international retail chains joined the Slovak retail market, for which the onset was characterised by the construction of «new sales formats», large-scale stores, for example discount stores, supermarkets, hypermarkets, shopping malls, etc., which fundamentally changed the functional, as well as spatial, model of the city (Matlovic, et al., 2001; Szczyrba, 2005; Krizan, 2009; Trembosova, 2010; Trembosova, 2012; Kunc, et al., 2013; Bacik, Stefko, & Gburova, 2014) [2; 12; 14-18]. Large-scale retail units were placed close to major transport routes, often «from scratch», which causes a change in the traditional shopping behaviour of consumers (Bacik, Szabo, & Fedorko, 2014) [19], in terms of weekend shopping, shopping for pleasure, change in the shopping place, etc. (Mitrikova, 2008; Krizan, 2009; Spilkova, & Radova, 2011; Spilkova, 2012; Trembosova, 2012; Kunc, et al., 2013; Civan, et al., 2014; Bilkova, Krizan, & Barlik, 2015) [2; 10; 12; 16; 20-23]. According to Krizan and Lauko (2014) [24], modelling expressing the relationship of the store location towards different variables can be considered to be a suitable research tool of retail chains. The literature dedicated to retail states multiple types of models; from the simplest gravity model to more demanding models with several variables (see Szczyrba, 2005; Trembosova, 2008; Trembosova, 2010; Lauko, & Krizan, 2014; Kunc, et al. 2013; Marjanen, 1995; Kapinus, Skryhun, & Semenenko, 2015; Stacho, Gubiniova, & Pajtkova Bartakova, 2015) [2; 15; 17; 24-26]. The models applying the retail geography are based on the concept of human aggregate gravity as written by Reilly (1931) [4], Huff (1963; 1964) [6-7] and other authors. The Huff model was in the Slovak Republic described and studied by Mitrikova, and Varga (2007; 2008) [29-30], Trembosova (2008) [25] and Mitrikova, Senkova and Antolikova (2015) [31]. In this article, the application of the Huff model was applied to selected large-scale retail stores in Kosice and compared with the results of the questionnaire survey which was performed in 2015.

3. The purpose of the article is to calculate the Huff model shopping probability for five selected large-scale stores within 22 urban areas of Kosice.

Methods and data. The Huff probability model takes into account the retail size, which is given by the sales area and its availability. The model defines the share of customer trips for shopping from the particular area to all centres within the research area. This share can be understood as a probability that a particular store will be selected as a target store by the citizens from that area. The Huff probability model is widely used in practice and has been the most frequently used model around since the mid-70s of the 20th century until today. The Huff model considers the pulling power of the store, relative to the total pulling power of all other stores within the region. The pulling power of the store depends on the size, distance and types of products on sale. This means that there are three main factors in calculating the probability contours (Newman and Cullen, 2002) [32]:

1. The size of the stores in the region (a larger store has a greater attraction for costumers, because they are more likely to find what they would like).

2. The time to travel to each store (a store further away is less attractive than one which is close because of the time lost and inconvenience caused by travelling).

3. The type of product the costumer is shopping for (the type of product affects the way that consumers balance the

attraction of store size against the inconvenience of travel to the store).

The Mathematical expression of the model is as follows:

$$P_{ij} = \frac{S_j}{T_{ij}^a} \cdot \frac{1}{\sum_{j=1}^n \frac{S_j}{T_{ij}^a}}, \quad (1)$$

where:

P_{ij} - the probability of consumer at a given point of origin i travelling to a particular shopping centre j ;

S_j - the size of a shopping centre j (measured in terms of the square meters of selling area);

T_{ij} - the travel time or distance involved in getting from a consumer's travel base i to a given shopping centre j ;

n - the number of all possible shopping places within the area i ;

a - the parameter expressing the willingness of a customer to overcome certain distance.

4. Results

Kosice, Slovakia's second largest city has a population of over 239,000 inhabitants. The location of this city is determined by the following coordinates: 48° 43' north latitude and 21° 15' east longitude. The northernmost point lies in the district Sever (48° 82' with SG., 21° 15' VGD?), the southernmost point is located in the city of Saca (48° 57' with SG., 21° 22' VGD), the westernmost point is located in the district Sever (48° 76' W sg., 21° 12' VGD) and the easternmost point is located in the city Krasna (48° 64' W sg., 21° 36' VGD). The maximum altitude is 851 m. n. m., the minimum altitude is 184 m. Downtown has an altitude of 208 m. n. m. Three geomorphological units extend within the city boundaries. They are Kosicka kotlina, Volovske vrchy and Cierna hora (Cuka, & Senkova, 2012) [33]. On the day of July 24, 1996, Act No. 221/1996 Coll. came into force, stating the territorial-administrative division of the Slovak Republic, under which the territory of Kosice consists of four districts. Lower territorial-administrative level consists of 22 urban areas, which formed the basis for this theoretical calculation of the Huff probability model. Each of the 22 urban areas represents the parameter « i », that is a location for which the Huff model of probability was measured; in this case it is the distance to a selected store « j ». To find the information about the distance, we used the shortest distance that can be reached through the road network from the Kosice city centre « j » to the geometrical centre of each local region « i ». The date was retrieved using the shortest path between two given points in the map portal Google Maps. The data obtained is the value of « T_{ij} » - the distance between the local region « i » and the store « j ». Further data, necessary to calculate the probability of choice, include the attractiveness of stores, which is determined by their retail space. The parameter « a » expresses the willingness of a customer to overcome certain distance. It is determined empirically and varies with the hierarchical level of the centre. Given the similarity of stores with the comparable supply of goods as well as similar attraction for customers, each of the stores was assigned the parameter 1. When calculating the denominator, we used the total sum of the retail space share (Figure 1) as well as the distance to local regions of all possible shopping places within the research area of Kosice (Table 1). The Huff model was calculated for five selected large-scale stores, and two shopping centres. They are OC Atrium Optima (32 Moldavska cesta Str.) and OC Galeria Shopping (5 Toryska Str.); and three hypermarkets Kaufland (92 Popradska Str.); Tesco Nad Jazero (16 Napajadla Str.); and Tesco Extra (1 Trolejbusova Str.).

Atrium Optima has the highest theoretical probabilities of purchase for residents of the urban area Lunik IX that is over 40%. The Huff model assumes that two out of five inhabitants of this urban area would choose Atrium Optima as the place of their purchase. This result is affected by good availability, because the urban area Lunik IX has the smallest distance, and that is 2.3 km from Atrium Optima, as well as by the sales area, which is the largest in Kosice. In contrast, only 7% of inhabitants of the urban area Dzungla would primarily do their

Tab. 1: Shopping options in Kosice with a sales area in year 2015

Kosice – Urban area	Name (j)	Sales area (Sj), m ²
Barca	Supermarket FRESH	1,753
Dargovskych hrdinov	LIDL	1,450
Dargovskych hrdinov	OC Hornad (Hnedak)	5,218
Dzungla	TESCO EXTRA	10,200
Juh	LIDL, Juzna trieda	1,150
Juh	OC Atrium Optima	50,600
KVP	OC Cassovia	24,700
	LIDL	1,350
	BILLA	2,100
Nad Jazerom	Hypermarket TESCO	3,000
Nad Jazerom	BILLA	864
Sever	BILLA	800
Sidlisko Tahanovce	Supermarket KLAS	1,250
Sidlisko Tahanovce	LIDL	1,550
Stare mesto	Obchodny dom TESCO	9,000
Stare mesto	LIDL, Stanicne namestie	1,000
Saca	AUPARK	34,000
	DARGOV	19,200
	Supermarket FRESH	1,215
Zapad	OC Galeria Shopping	30,000
Zapad	LIDL, Moldavska Str.	1,200
	LIDL, Popradska Str.	1,350
	BILLA, Bardejovska Str.	1,020
	Kaufland, Popradska Str.	5,640

Source: Own research

shopping in this centre, which is the lowest rate among all urban areas. Again, it is not just the greater distance (8.2 km), but also other shopping options, which are for residents of this urban area of Dzungla closer, for example Tesco Extra which is located directly in this urban area. Despite the fact that the large-scale retail OC Atrium Optima and the hypermarket Kaufland are relatively close to one another (about 500 meters), the results of calculations are different. This is due to higher attractiveness of OC Atrium Optima expressed via more floor space, and the store is therefore more preferred. The maximum theoretical degree of probability of shopping among residents of the urban area of Lunik IX is about 4%. This result is affected by the small distance to the supermarket, as well as by other options for shopping. The lowest level of probability has the urban area of Dzungla. The calculation results according to the Huff model for the OC Atrium Optima shopping mall, as well as the hypermarket Kaufland, are shown in Table 2. The highest shopping probability was calculated for both large-scale stores for residents of the urban area Lunik IX. The reason was not only due to the good access to these shops, but also to the share of retail space in these stores which are located close to the given urban area. The stores were calculated as the least likely for shopping in relation to citizens of the urban area Dzungla.

The Calculation results of the Huff model for OC Galeria Shopping (Table 3) show that the maximum theoretical results gained the urban area of Zapad, on whose territory the large-scale store is located, and comprise almost 57%. The second place belongs to the urban area of KVP. This suburban area is only 2.3 km away, and the accessibility is excellent. For KVP, the theoretical

Tab. 2: Calculation results of the Huff model for OC Atrium Optima (32 Moldavska cesta Str., urban area Juh) and Hypermarket Kaufland (92 Popradska Str., urban area Zapad)

Kosice –Urban area	stores		Kosice – Urban area	stores	
	O	K		O	K
Barca	26.59	2.62	Nad Jazerom	25.70	2.32
Dargovskych hrdinov	13.97	1.33	Peres	34.33	3.57
Dzungla	7.58	0.96	Polov	31.02	3.29
Juh	18.45	2.33	Sever	14.85	1.60
Kavecany	19.14	2.19	Sidlisko Tahanovce	9.34	1.18
Kosicka Nova Ves	13.40	1.49	Stare mesto	11.75	1.47
Krasna	22.43	2.33	Saca	23.77	2.58
KVP	17.86	2.28	Sebastovce	24.95	2.57
Lorincik	28.20	2.99	Tahanovce	13.04	1.58
Lunik IX	40.83	3.88	Vysne Opatske	11.99	1.28
Myslava	26.48	3.12	Zapad	20.34	2.89

Note: Store O - shopping centre Atrium Optima, K - hypermarket Kaufland,
Source: Own research

attractiveness was 22.88%. The lowest appeal of OC Galeria is on the side of the urban area Sever which is located 6.6 km and comprises 11.35%. However, within the area of Sever there are also other large-scale retail stores.

According to the calculations of the probability theory, the hypermarket Tesco Extra (Table 4) is the biggest attraction for the urban area of Dzungla in which the hypermarket is located (23.48%). This has profound effects on the residents and store in the urban area of Dargovskych hrdinov, 13.11%, which is neighbouring the urban area of Dzungla. The urban area of Tahanovce is on the fourth place, stating that its inhabitants theoretically buy from Tesco Extra with a probability of 9.99%. Although the availability of the inhabitants of this urban area is good, there is a number of other large-scale retail stores which struggle for their customers' attention, shrinking the appeal of the hypermarket Tesco Extra. The smallest attraction was calculated for the residents of the urban area Zapad (1.45%), with the dominant OC Galeria shopping centre.

This large-scale retail store is located in the urban area Nad Jazerom and appeals to its citizens with 6.31%. This shop has profound effects on the population of the neighbouring urban area of Krasna with 3.48%. In the interval from 1.0 to 2.0%, the hypermarket Tesco appeals to the following urban areas (ascending): Kavecany, Peres, Tahanovce (village), Polov, Kosicka Nova Ves, Saca, Lorincik, Vysne Opatske, Sebastovce. In the interval from 0.0 to 1.0% is the attraction of the hypermarket Tesco as follows (ascending): Zapad (0.35%), Old Town, KVP, Sever, Dzungla, Juh, Myslava, Tahanovce, Dargovskych hrdinov, Lunik IX, Barca.

Tab. 3: Calculation results of the Huff model for OC Galeria Shopping (5 Toryska Str., urban area Zapad)

Kosice – Urban area	G	Kosice – Urban area	G
Barca	12.72	Nad Jazerom	12.24
Dargovskych hrdinov	12.21	Peres	13.75
Dzungla	12.25	Polov	13.23
Juh	16.88	Sever	16.77
Kavecany	15.76	Sidlisko Tahanovce	11.35
Kosicka Nova Ves	12.41	Stare mesto	15.43
Krasna	13.40	Saca	13.17
KVP	22.88	Sebastovce	13.37
Lorincik	16.05	Tahanovce	14.66
Lunik IX	15.52	Vysne Opatske	13.13
Myslava	22.30	Zapad	57.52

Note: Store G - shopping centre OC Galeria Shopping
Source: Own research

5. Conclusions

The Huff model presents a general theoretical picture of the likelihood of purchase in the store. However, when applied in practice, certain factors that affect this theoretical conception have to be taken into the account, for example the quality and quantity of goods, quality of services, pleasant atmosphere in stores, cleanliness, social, cultural and demographic aspects (age structure of the population of cities), economic aspects (for example customer income differentiation) and many other factors affecting consumer preferences of a particular store. As it has already been mentioned above, the highest theoretical probability for the shopping mall Atrium Optima has been calculated on the side of Lunik IX residents. However, these figures cannot be considered relevant since the inhabitants of this urban area are economically weaker and, therefore, do not have sufficient income to prefer one shopping centre to another. However, these factors cannot be incorporated into any models, since each store is specific and cannot fully embrace general

Tab. 4: Calculation results of the Huff model for the hypermarket Tesco Extra (Trolejbusova Str., urban area Dzungla) and for the hypermarket Tesco Nad Jazerom (16 Napajadla Str., urban area Nad Jazerom)

Kosice – Urban area	stores		Kosice – Urban area	stores	
	TE	T		TE	T
Barca	2.84	0.97	Nad Jazerom	3.07	6.31
Dargovskych hrdinov	13.11	0.84	Peres	2.71	1.05
Dzungla	23.48	0.77	Polov	2.98	1.08
Juh	2.58	0.79	Sever	8.02	0.66
Kavecany	6.62	1.03	Sidlisko Tahanovce	9.99	0.84
Kosicka Nova Ves	6.42	1.08	Stare mesto	2.57	0.45
Krasna	3.63	3.31	Saca	3.24	1.17
KVP	2.70	0.66	Sebastovce	3.24	1.81
Lorincik	3.48	1.28	Tahanovce	12.71	1.06
Lunik IX	2.06	0.88	Vysne Opatske	5.25	1.42
Myslava	2.67	0.82	Zapad	1.45	0.35

Note: Store TE- hypermarket TESCO Extra,

T - hypermarket TESCO Nad Jazerom

Source: Own research

assumptions and findings. Therefore, it can be concluded that there are limitations to the use of the Huff theoretical model because, if following the relationship of shopping and places of purchases, there must always be the rational consumer behaviour. This refutes the previously held view that a man prefers minimal mobility in order to buy something and behaves economically. Nevertheless, it turns out that a certain proportion of customers chooses the shopping place based on other factors as well, for example by its wide range of goods, good services, variety of services, size, attractiveness and atmosphere of the shop and so on. Experience has shown that people bound by good access and economic factors often do not respect the logic of economic thinking. Therefore, the Huff model cannot be regarded as objective in identifying the preferences of large-scale stores within urbanised areas. Therefore, in the future, it is necessary to compare the results from the theoretical model calculations with the ones from the empirical research.

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