APPLICATION OF THE HUFF'S PROBABILITY MODEL ON SELECTED LARGE-AREA RETAIL UNITS IN KOŠICE IN THE CONTEXT OF TRANSFORMATIONAL CHANGES IN RETAIL AFTER 1989 IN SLOVAKIA

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Abstract
Application of the Huff's probability model on selected large-area retail units in Košice in the context of transformational changes in retail after 1989 in Slovakia
After 1989 there have been rather significant qualitative and spatial changes in retail trade network in Slovakia. The behaviour of trader as well as consumer is changing. Supranational trade networks with their large hypermarkets are penetrating our trade. In last four years the share of hypermarket shopping in Slovakia has increased more than twice, and the share of small shops and counter shops is decreasing despite the fact that they keep the highest average annual shopping frequention. Hypermarkets continuously make a profit of new customers.

Key words
retail, shopping behaviour, Slovakia, hypermarket, retail store, intensity of attendance, accessibility area of attendance, the Huff´s probability model

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Introduction

The construction of large-area retail units in Slovakia has consequently changed the shopping behaviour of its inhabitants. They start to prefer the individual car transport and reduce the public or pedestrian one, since the shopping centres concentrate themselves mostly in the city outskirts. People usually do shopping in the afternoon and in the evening. Saturday and Sunday are the most popular days in week for shopping. Thus, we can see that the former models of shopping behaviour are changing and become more identical with those of the western Europe.

Mowen (1987) considers that the discipline of consumer´s behaviour is dealing with generation of decisions concerning the processes of acquirement, consumption and use of goods, services, and ideas. The creation of decision is, as he writes, an important basis, whereas it often occurs in groups, families, in firm´s management etc. The acquirement process includes the communication, remembering, and considering acquired information (Mowen 1987).

Behavioural geography, according to Walmsley and Lewis (1984), is trying to find a relation between consumers´behaviour and spatial structure of retail trade environment. It used to be supposed that a man prefers the minimal mobility towards shopping and behaves in favour of economic nature. Later studies has proved that a part of consumers select the place of shopping not only by the goods offer and services, size, attractiveness and good atmosphere of the shop. Researches have revealed that people do not respect the logic of objectiveness and behave irractionally (Walmsley and Lewis 1984). It means that if there was built a supermodern shopping centre with perfect services and low prices near the city, not all people from its surroundings would do their shopping there, and on the other hand, many people from more distant areas might do shopping there (Szczyrba 2002, 2005).

2.1 Huff's probability model

The Huff's probability model is based on a classic gravitation model, which can be considered as the earliest type of spatial models, and which was formulated on the basis of analogy with the Newton's universal gravitation law. Gravitation models were first used only for demographic research and it was only after 1930's that they were used also for definition of retail and services centres' tributary areas. Among others, following Slovak authors worked in the field of application and issues of gravitation model: Bezák (1999, 2000), Bezák and Michniak (1999), Kusendová (2001), Kusendová and Labuda (2002), Paulov and Poláčik (1979, 1982), Paulov (1986b, 1991, 1993). Hebák (1972) used the possibility of application of gravitation model in quantification of retail tributary area, Čadková and Krásný (1985) used it for definition of the tributary area of service centres for citizens.

The best known gravitation model is the so called Reilly's law of retail gravitation. It is a formula stating that two bigger areas divide among themselves the purchase demand of a town situated between them, suggesting that customers are drawn from the intermediate town at or close to the point of equal probability, approximately in direct proportion to the population of the two shopping areas and in inverse proportion to the squares of the distance between the town and the two shopping areas. This model does not take into account all the aspects that influence

the division of smaller intermediate town population spending between the two shopping areas (transport possibilities, communication network quality, population density, trade and social activity of the retail municipalities, geographical conditions, social and income differentiation of customers, etc. (Pražská and Jindra et al. 1998, Szczyrba 2005).

This basic model can distort reality, as it considers the sphere of influence of shopping areas to be closed and mutually exclusive. However, the research proved the existence of intermediate areas the population of which commutes more or less regularly to two or more retail centres. The definite breaking point between particular centres can be used especially in the situation where the distance from the retail centres is the determining factor and where the choice is minimal (i.e. mainly in countryside environment). In more urbanised areas more retail centres operate in individual municipalities and thus the possibility of choice is growing. *Huff's probability model* reacts to this fact. It considers size of the shop, defined by the shopping floor area, and its temporal accessibility. It defines proportion of purchase journeys from a particular municipality to all retail centres of the analysed area. This proportion can be considered a probability that a certain retail centre will be a target shopping area for the inhabitants of the municipality. This model can be applied broadly and it has been the most widely used model since the 1970's (e.g. for localisation of retail units and service centres). However, even in spite of the fact that it is a widely used model, content of individual parameters remains problematic. The model (Pražská – Jindra et al., 1998, Szczyrba 2006) is stated as:

$$P(Cij) = \frac{\frac{Sj}{Tij\lambda}}{\sum_{j=1}^{n}\left[\frac{Sj}{Tij\lambda}\right]}$$

Where:

- $P(C_{ij})$ – probability that the municipality i inhabitants will shop in the retail centre j
- S_j – size of the retail centre j given by shopping floor area
- T_{ij} – temporal accessibility of the retail centre j from municipality i
- Λ – parameter, which changes according to hierarchical level of the retail area (empirically)

2.2 Application of the model to selected large-area retail units

For this article, the Huff's model was applied to four particular large-area retail units in city of Košice. The aim of this application was to compare the probability of inhabitants of particular city parts (wards) shopping in a selected large-area retail unit. Temporal accessibility of retail centre j from municipality i was replaced by the spatial distance of retail centre j from municipality i in calculation of probability. The reason for this replacement was the lack of objectiveness of the temporal accessibility data, as this is very difficult to measure due to various reasons. The model was applied to 4 different retail units, one of which is the largest retail-centre in Košice (Optima) and the remaining three are less important retail (discount) units Lidl, due to both their shopping-floor area and the variety of offered goods. Since retail centre (mall) and discount retail unit differ in many aspects, the aim of this paper is to compare gravitation of individual stores.

Tab.1: Application of the model to selected large-area retail units.

City part	$\sum_{j=1}^{n}\left[\frac{Sj}{Tij\lambda}\right]$ without OPTIMA a LIDL	$\frac{Sij}{Tij\lambda}$ (OPTIMA)	$\frac{Sij}{Tij\lambda}$ (LIDL Darg. hrd)	$\frac{Sij}{Tij\lambda}$ (LIDL KVP)	$\frac{Sij}{Tij\lambda}$ (LIDL Západ)
Staré mesto	33530.33	2250	248.2	98.93	145.18
Barca	3109.72	1777.78	20.57	23.11	30.72
Dargovských hrdinov	4124.91	599.38	203.18	24.73	26.34
Džungľa	98293.39	1306.12	1400	64.2	75
Kavečany	1465.38	369.17	27.58	29.62	20.64
Košice- JUH	22450.96	9000	77.51	64.2	113.61
Košice – SEVER	9465.56	1306.12	155.56	144.44	105.35
Košice – ZÁPAD	30332.51	10240	65.45	369.78	1200
Košická Nová Ves	4713.1	959.6	185.12	23.9	30.72
Krásna	1792.83	661.88	22.58	13.33	15.67
KVP	13507.02	4355.39	46.28	1697.96	634.71
Lorinčík	3986.78	3160.49	17.28	71.97	70.52
Luník IX	18579.76	36000	30.73	133.12	237.04
MČ KE- Sídlisko Ťahanovce	3305.34	483.93	122.91	26.53	24.49
Myslava	5750.9	2739.6	28.57	369.78	158.68
Nad Jazerom	5500.93	2250	35.84	25.61	34.77
Pereš	7170.01	7111.11	22.58	106.12	122.88
Poľov	2880.42	2115.7	14	30.77	37.93
Šaca	829.34	457.05	6.33	12.68	11.42
Šebastovce	2404.64	1370.61	14.73	19.1	23.64
Ťahanovce	2743.58	457.05	93.24	25.61	23.64
Vyšné Opátske	9504.36	2115.7	99.56	37.66	53.19

Main differences between large-area retail stores Optima and Lidl:

- Optima is a retail centre (mall), Lidl is a discount retail unit .
- Optima offers a wider variety of goods than Lidl stores.
- There are 89 smaller shops situated in the shopping gallery of Optima retail centre, Lidl stores do not have a shopping gallery.
- Area of Optima is 36000 m^2, area of a Lidl store is 1200 – 1400 m^2.
- The developer of Optima retail centre was Optima Corporation Bratislava. The main partners of the project were TK Development and Ahold Real Estate. TK Development was responsible for building of the shopping gallery, Ahold was responsible for Hypernova hypermarket. All retail units Lidl in Slovakia are

operated by a trading company Lidl Slovenská republika, v.o.s. There are 60 Lidl discount retail units in Slovakia at present (3 in Košice) and 1 logistic centre in Nemšová.

- Shopping floor area of Optima is divided between the shopping area of Hypernova store (15 000 m^2) and shopping gallery (21 000 m^2), shopping area of Lidl represents solely the shopping floor of the discount retail unit.

Table 2: Application of the model to selected large-area retail units.

City part	$\sum_{j=1}^{n}\left[\frac{Sj}{Tij\lambda}\right]$ without OPTIMA	$\sum_{j=1}^{n}\left[\frac{Sj}{Tij\lambda}\right]$ without LIDL Darg. hrd.	$\sum_{j=1}^{n}\left[\frac{Sj}{Tij\lambda}\right]$ without LIDL KVP	$\sum_{j=1}^{n}\left[\frac{Sj}{Tij\lambda}\right]$ without LIDL Západ	$P(C_{ij})$ OPTIMA	$P(C_{ij})$ LIDL Darg. hrdinov	$P(C_{ij})$ LIDL KVP
Staré mesto	34022.64	36024.44	36173.71	36127.46	0.066132434	0.006889767	0.002734859
Barca	3184.12	4941.33	4938.79	4931.18	0.558326947	0.004162847	0.004679284
Dargovských hrdinov	4379.16	4775.36	4953.81	4952.2	0.136870998	0.042547578	0.004992117
Džungľa	99832.59	99738.71	101074.51	101063.71	0.013083102	0.014036676	0.000635175
Kavečany	1543.22	1884.81	1882.77	1891.75	0.239220591	0.014632775	0.015732139
Košice- JUH	22706.28	31628.77	31642.08	31592.67	0.396366115	0.002450617	0.002028944
Košice – SEVER	9870.91	11021.47	11032.59	11071.68	0.13232012	0.01411427	0.013092121
Košice – ZÁPAD	31967.74	42142.29	41837.96	41007.74	0.320322926	0.001553072	0.008838385
Košická Nová Ves	4952.84	5727.32	5888.54	5881.72	0.193747426	0.032322273	0.004058731
Krásna	1844.41	2483.71	2492.96	2490.62	0.358857304	0.009091239	0.005347057
KVP	15885.97	20195.08	18543.4	19606.65	0.274165821	0.002291647	0.091566811
Lorinčík	4146.55	7289.76	7235.07	7236.52	0.762197489	0.002370448	0.009947381
Luník IX	18980.65	54949.92	54847.53	54743.61	1.896668449	0.000559236	0.002427092
MČ KE-Sídlisko Ťahanovce	3479.27	3840.29	3936.67	3938.71	0.139089522	0.032005395	0.006739198
Myslava	6307.93	9018.96	8677.75	8888.85	0.434310463	0.003167771	0.042612428
Nad Jazerom	5597.15	7811.31	7821.54	7812.38	0.401990299	0.004588219	0.003274291
Pereš	7421.59	14510.12	14426.58	14409.82	0.958165299	0.001556155	0.007355867
Poľov	2963.12	5064.82	5048.05	5040.89	0.714010907	0.002764165	0.006095423
Šaca	859.77	1310.49	1304.14	1305.4	0.531595659	0.004830254	0.009722883
Šebastovce	2462.11	3817.99	3813.62	3809.08	0.556681058	0.003858051	0.005008365
Ťahanovce	2886.07	3249.88	3317.51	3319.48	0.158364142	0.02869029	0.007719645
Vyšné Opátske	9694.77	11710.91	11772.81	11757.28	0.218231067	0.008501474	0.003198896

City of Košice is divided into 22 city parts (wards) and each of these represents parameter *i*, which is a parameter of a location from which the distance to the analysed retail unit is measured (and in parameter Tij temporal accessibility was replaced by distance). Average distances of each city ward ((maximum distance + minimum distance)/2) from a selected large-area retail unit were used in calculations.

According to the Huff's model, the highest probability that Optima centre will be a target for shopping of its inhabitants are in the city parts Luník IX, Pereš and Lorinčík. This is determined by both the closeness of these parts to the retail centre and the fact that no other store, included in this research, is situated in these city wards. In this case we can see the disadvantages of this theoretical model, since it does not take into account some factors that influence the results of the research. In case of Luník IX this factor is a social pattern of its inhabitants. These inhabitants usually shop in other large-area stores, which offer cheaper goods yet their range of goods is smaller and less varied (e.g. Kaufland or Lidl). It is interesting that the city ward, in which Optima is situated, did not reach the highest number of probability calculations according to the Huff's model. This is caused by location of other retail units in this area. City ward JUH, in which Optima is located, is also a city ward with the highest number of large-area stores in the city of Košice, and thus the probability of shopping here is not as high as in Luník IX, Pereš and Lorinčík parts, where none of the analysed retail units are situated. The result of the lowest probability of shopping in Optima retail centre was also very interesting. The lowest probability was not reached by the most distant parts of the city, but by the city ward Džungľa. This result was influenced mainly by the fact that two relatively large stores are situated in this part of the city (Tesco and Baumax) and also the fact that Optima is one of the most distant stores from this part of the city. Similar probability results for the city ward Džungľa were calculated in case of the Lidl retail unit situated in the city ward of Dargovských hrdinov. Even though it is in a close proximity of this retail unit, the probability of shopping there is much lower than in other neighbouring parts of the city. It is caused by the fact that large-area retail stores are situated in this smallest city ward Džungľa. As expected, the highest probability, according to the Huff's model, was reached by the city ward of Dargovských hrdinov, where the retail unit is also situated. The lowest probability of shopping is not in the most distant part of the city but in the city ward Luník IX. This is caused by the closeness of other large stores (in the city ward JUH).

In case of Lidl retail units in the KVP and Západ housing estates, the lowest probability of shopping again applies to the Džungľa city part, due to he same reasons as mentioned above in case of Optima retail centre. There were no unexpected results in other calculations.

All calculations are reflected in the maps in Figure 1. As it can be seen, the probability of shopping depending on distance decreases more slowly in case of Optima retail centre (Figure 1A). On the other hand, it can be seen from pictures 1B, 1C and 1D that the probability of shopping decreases more rapidly depending on distance. The size of the stores has a significant influence on this as well.

Table 3: Application of the model to selected large-area retail units.

City part	$P(C_{ij})$ LIDL Západ	$P(C_{ij})*1000$ OPTIMA	$P(C_{ij})*1000$ LIDL Darg. hrd.	$P(C_{ij})*1000$ LIDL KVP	$P(C_{ij})*1000$ LIDL Západ
Staré mesto	0.00401855	66.13243417	6.889767058	2.734859101	4.018549879
Barca	0.006229746	558.3269475	4.162846845	4.679283792	6.229746227
Dargovských hrdinov	0.005318848	136.8709981	42.54757756	4.992117178	5.318848189
Džungľa	0.000742106	13.08310242	14.03667643	0.635174981	0.742106143
Kavečany	0.010910533	239.2205907	14.63277466	15.73213935	10.91053258
Košice- JUH	0.003596087	396.3661155	2.450616954	2.028943736	3.59608732
Košice – SEVER	0.009515268	132.3201204	14.11426969	13.09212071	9.515267782
Košice – ZÁPAD	0.029262768	320.3229255	1.553071748	8.838385046	29.26276844
Košická Nová Ves	0.005222962	193.7474257	32.3222729	4.058731027	5.222961991
Krásna	0.006291606	358.857304	9.09123851	5.347057313	6.291606106
KVP	0.03237218	274.1658205	2.291647273	91.56681083	32.37217985
Lorinčík	0.009745016	762.1974895	2.37044841	9.947381297	9.74501556
Luník IX	0.004330003	1896.668449	0.559236483	2.427091977	4.330003082
MČ KE- Sídlisko Ťahanovce	0.006217772	139.0895217	32.00539543	6.739198358	6.217771809
Myslava	0.017851578	434.3104632	3.167771007	42.61242834	17.8515781
Nad Jazerom	0.004450628	401.9902986	4.588218877	3.274291252	4.450628362
Pereš	0.008527518	958.1652988	1.55615529	7.35586674	8.52751804
Poľov	0.007524465	714.0109074	2.76416536	6.095422985	7.524464926
Šaca	0.008748276	531.5956593	4.830254332	9.722882513	8.74827639
Šebastovce	0.006206223	556.6810581	3.858050964	5.008364756	6.206223025
Ťahanovce	0.007121597	158.3641422	28.6902901	7.719645156	7.121597359
Vyšné Opátske	0.004524006	218.2310669	8.501474266	3.19889644	4.524005552

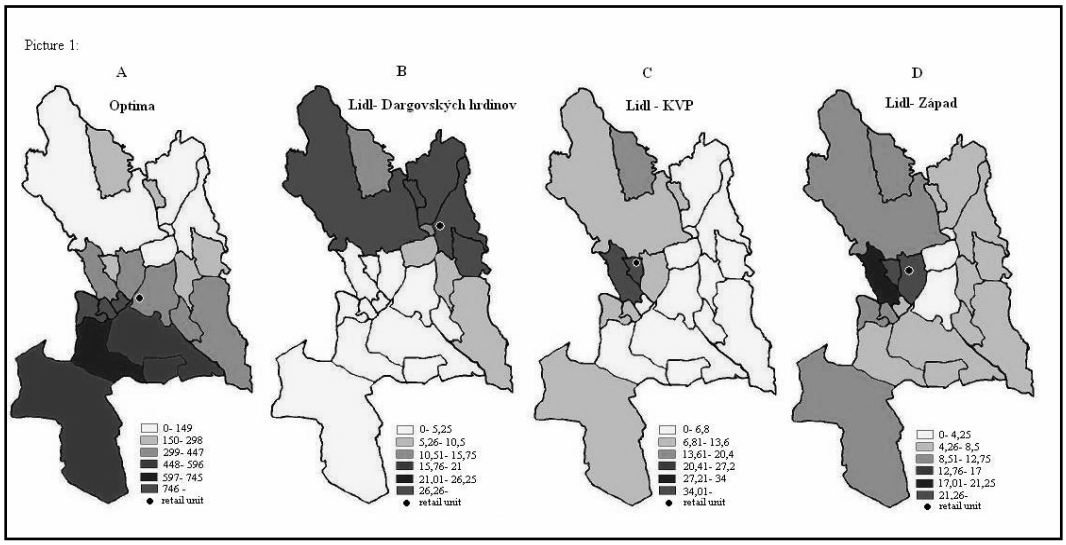

Fig.1: Application of the model to selected large-area retail units.

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Literature

Bezák, A. 1999: Comparing the approaches to migration flow projections: The case of interregional migration in Slovakia. In: Acta Facultatis Rerum Naturalium Universitatis Comenianae, Geographica Supplementum No. 2/I, 1999, Bratislava, P. 11 – 22.

Bezák, A. 2000: Inrerregional migration in Slovakia: some tests of spatial interaction models. In: Geografický časpis, vol. 52, 1999, No 1.

Bezák, A., Michniak, D. 1999: Niekoľko predbežncýh úvah o dostupnosti okresov miest na východnom Slovensku. Acta Facultatis Studiorum Humanitatis et Naturae Universitatis Prešoviensis, Folia Geographica, 3, p. 191-197.

Čadková, B., Krásný, T. 1985: Příspěvek k modelovému vymezování spádu do středisek občanské vybavenosti. Sborník ČSGS, 90, č. 4, Praha, s. 269 – 278.

Fertaľová, J. 2005a: Regionálnogeografické aspekty hodnotenia vývoja maloobchodu na Slovensku po roku 1989. In: Acta Facultatis Studiorum Humanitatis et Naturae Universitatis Prešoviensis, Prírodné vedy, XLIII., Folia geographica 8. Prešov: FHPV PU, 2005, p. 5-12.

Fertaľová, J. 2005b: Some methodological issues in classification of retail stores (with examples from European countries). In: Acta Facultatis Studiorum Humanitatis et Naturae Universitatis Prešoviensis, Prírodné vedy, XLIII., Folia geographica 8. Prešov: FHPV PU, 2005, p. 13-19.

Fertaľová, J., Szczyrba, Z. 2006a: Globalisation in the Czech and Slovak retail: Common and Specific Features. In.: Siwek, T., Baar, V. (eds.): Globalisation

and its Impact to Society, Regions and States (sborník příspěvků z mezinárodní konference). Ostravská univerzita, Ostrava, s. 164-173.
Hebák, P. et al. 1972: Možnosti využití gravitačních modelů pro kvantifikaci nákupního spádu. VÚO, Praha. p. 152.
Križan, F. 2004: Dostupnosť slovensko-maďarského pohraničia. In: Wahla, A. ed.: Geografie a proměny poznání geografické reality. Ostrava, p. 266-271.
Križan, F. 2005: Analýza dostupnosti vybraných maloobchodných sietí Slovenska (príkladová štúdia siete Billa). Zborník zo VI. vedeckej konferencie doktorandov a mladých vedeckých pracovníkov, Nitra, pp.237-240.
Križan, F. 2005: Meranie dostupnosti v geografii. Geografické aspekty středoevropského prostoru, Brno: Masarykova univerzita v Brne, p. 267-287.
Kusendová, D. 2001: Použitie modelu populačného potenciálu vo výskume regionálnej diferenciácie Slovenska. In: Súčasný populačný vývoj na Slovensku v európskom kontexte. Zborník príspevkov 8. demografickej konferencie, Bratislava: Slovenská štatistická spoločnosť, 2001, p.90 – 94.
Kusendová, D.,Labuda, R. 2002: Gravitačné modelovanie dochádzky za prácou v okrese Veľký Krtíš. In: Geografické informácie 7, Zborník z XIII. Kongresu SGS I. diel – Slovensko a integrujúca sa Európa. P. 126-139.
Mowen, J. 1987: Consumer Behavior. Macmillan, New York.
Paulov, J., Poláčik, Š. 1979: Kalibrácia a testovanie gravitačného modelu na migračných dátach. In: Acta Facultatis Rerum Naturalium Universitatis Comenianae, Geographica Nr. 17,1979, Bratislava, p. 209 – 232.
Paulov, J., Poláčik, Š. 1982: Interakčný model: Kalibrácia a testovanie. In: Studia Geographica, 1982, Nr. 74, p. 75 – 94.
Paulov, J. 1986: Gravitačný model: Analytický nástroj štruktúrneho výskumu v geografii. Acta Facultatis Rerum Naturalium Universitatis Comenianae, Geographica Nr. 25, 1986, Bratislava, p. 79 – 99.
Paulov, J. 1991: Priestorová interakcia a jej modelovanie.Habilitačná práca. Bratislava, PrirF UK.
Paulov, J. 1993: Entropia v urbánnej a regionálnej analýze: konceptuálny rámec a základy aplikácie. In: Geographia Slovaca, 1993, Nr. 2, Bratislava, Geografický ústav SAV.
Pražská, L., Jindra, J. et al. 1998: Obchodní podnikání – Retail management, Management Press, Praha.
Szczyrba, Z. 2002: Shopping gravity of large-scale stores – example of Terno Olomouc hypermarket (Contribution to the study of the problematic). Geographica 37, p. 91 – 96.
Szczyrba, Z. 2005: Maloobchod v ČR po roce 1989. Vývoj a trendy se zaměřením na geografickou organizaci. PřF Univerzity Palackého Olomouc. p.126.
Szczyrba, Z. 2006: Geografie obchodu – se zaměřením na současné trendy v maloobchodě. Přirodovědecká Fakulta UP Olomouc. p. 90.
Tolmáči, L., Lauko, V., Križan, F. 2005: Development of the network of super and hypermarkets in Slovakia after 1990 and its accessibility. In Sammelband (Hsg. Zsilincsar): Neue Einzelandelstrukturen am Rande von Kleinstädten, Tagung Forschungssechseck Hartberg 15. – 16. 10. 2004. Institut fűr Geographie und Raumforschung Karl-Franzens-Universität Graz. p. 29 - 44.
Walmsley, D. J., Lewis, G. J. 1984: Human geography: Behavioural approaches. Logman Group, London. p. 303.

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Summary

Huff's model offers a general and theoretical picture of probability of shopping in a particular retail store. Yet, in its application, we have to take into account the factors as e.g. social, cultural, demographic and economic aspects; accessibility of the stores; and many other factors, which influence this theoretical conception. These, however, can not be incorporated into any model, as every environment is very specific and there are no general expectations and findings that apply in all cases. Therefore, the results of the questionnaire research implemented at present will be used for comparing of the results, using the Huff's probability model of shopping in selected retail units in a specific city ward of Košice, with the outcome of the research.