Review

Using new Huff model for predicting potential retail market in South Korea

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This study sets out to reinvestigate the existing theoretical models (that is, the Huff Model, the new probability model, and the gravity model) for the following two critical reasons: (1) it is because the precedent models have seldom predicted an estimation of sales potentials at the opening of stores particularly at local markets in Korea and (2) it is also because the existing models did not offer specific factors affecting success in estimating a sales volume at the point of opening in local markets. The current study, thus, proposes a new formulation (model) which can precisely predict a sales potential volume at the opening of stores at a particular large local market located in Daejeon, Korea. From the newly-established formulation (model), some locally-specified factors affecting success in estimating a sales volume at the point of opening are incubated. And it is suggested that advertising expense, sales promotion expense, and top-of-mind store brand recognition of/on each store have been found to impact profoundly on increasing a sales volume at the inceptive business stage. The study, however, has found a limitation that the number of samples of this study is only four major department stores. Future research needs to include some more samples expanded with other cities and Eastern Asia countries.

Key words: The Huff model, the new probability model, the gravity model, top-of-mind brand recognition.

INTRODUCTION

In Korea, a large number of market researchers have tried to explain consumer behaviors in diverse market settings in conjunction with various approaching models. However, the existing models scarcely predict esti-mations of sales and consumption applied directly to local stores. Although two studies (that is, the Huff model and the new probability model) have been actively used in Korea to estimate the volume of sales, they have relied heavily upon (λ) mainly because they have not included various possible factors.

For this, this study examines limitations of precedent models by using some precedent cases on estimation of sales of local stores. This is to propose a model along with factors leading to a more accurate estimation of

sales volume when opening a store in local markets in the Korean context. The model could serve as a guiding reference for follow-up studies of this kind.

This study begins to examine sales of stores by using the precedent models such as (1) the Huff model - used widely to investigate market areas, (2) the new Huff model - designed by Youn et al. (2007). This investigation aims to explore not only limitations of the existing models but also some possible factors that affect sales volume.

For the investigation, the current study analyzes financial statements of some department stores in Daejeon, a large local city situated in the middle of Korea, because the basic data could be collected such as sales, advertising expenses, sales promotion and so on. There is not a lot of cities to analyze market area because of the Korea's territory like the nature of urbanization and high population density. It is easy to analyze Daejeon owing to the independent commercial area on other cities.

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This is to measure a scale of each store, an actual sales volume of each store, and an average travel time of vehicles at the center of the market area; then, to substitute all of the measurements for the formula of each model and compare results of one another. The study from the comparison and analysis establishes a research model by setting up such variable as outlay (that is, advertisement, sales promotion, and store recognition to measure sales volume). This study is based on data collected in 2005, because the precedent studies were based on them in 2000. A spreadsheet of Microsoft Excel 2003 is used to examine correlation with changes of the sales depending upon the variables.

REVISITING THE EXISTING MODELS

One of the most important decisions retailers have to make is the choice of a store's location (Craig et al., 1984). For selecting the right location, return on investment is the most important decision criterion (Krause-Traudes et al., 2008). Therefore, retailers need to evaluate what the potential sales of a new store will be. Three approaches to estimate the potential sales for a store at the location are (1) the Huff gravity model, (2) regression analysis, and (3) the analog model (Levy and Weitz, 2007).

In this study, we focus on the Huff gravity model, which is widely used in retailing practice (Hernandez, 2000) because of (1) its ease of use (Park et al., 2006; Lv et al., 2008) and (2) the accuracy of its predictions (Drezner and Dressner, 2002), even though the two-variable specification is too parsimonious for policy purposes (Gautschi, 1981). Several empirical studies (Huff and Blue, 1966) support the usefulness of the Huff model in predicting the market share of shopping centers (Craig et al., 1984).

In this model, the probability that customer I shops at location J depends upon two factors: the size of the store and the time it takes to travel to the store (Levy and Weitz, 2007)—the larger the store, the greater the probability of shopping, while the greater the travel time or distance, the lower the probability. The mathematical formula is as follows (Huff, 1964):

$$P_{ij} = (S_j / T_{ij}^{\lambda}) / (\sum S_j / T_{ij}^{\lambda})$$

where Pij denotes the probability that customer i shops at location j, Sj is the size of the store at location j, Tij is the travel time for customer i to get to loation j, and λ is a parameter that is to be estimated empirically to reflect the effect of travel time on various kinds of shopping trips.

The conditions for the experiments was set as follows: The test area (I) is optionally selected, and consumers understand that all the stores manage to sell both goods and services and that travel time and distance to each store are only the matter of difference.

Test 1: It takes the same time for consumers to reach all of the stores with different sizes

At first, all of T_{ij} are fixed at 10 in Table 1, while S_j increases 10 each from 10 to 100. S_j 1 makes change to a specific rate which leads to make the change of P_{ij} accordingly and to have the constant range of fluctuation. This, in other words, indicates that the probability makes change in proportion to store size.

Test 2: Stores having the same size and different travel times

Table 2 is the probability varies upon travel time; S_j is fixed at 10 while T_{ij} increases 10 each from 10 to 100. T_{ij} had the constant range of the fluctuation, and P_{ij} of No.1 store is 64.53% (the highest). P_{ij} of No.2 store is 16.13%, and the range of fluctuation between No.1 and No.2 store shows 48.4%. P_{ij} does not change greatly, when T_{ij}, the unit of 10 min is set again to make a change by the unit of 1 min.

When a store, equipped with the same size and conditions except the time, is placed at a 1 min distance, the probability to visit between No.1 store and No.2 store differs more than 48%.

In Daejeon, stores have different sizes as shown in the tests, and major competing stores are placed either within the same travel time on average or about 1 min from the downtown. If the stores are placed under the same condition as seen from the tests, the Huff model may produce more than 48% difference of visit probability and have different sales volumes. However, such a thing may be difficult to explain different sales between stores and would not be practical, because there would be many other factors such as advertising expense, sales promotion expense, and top-of-mind store brand recognition. Therefore, when many competing stores are concentrated at one market area like Daejeon, the Huff model may be very much difficult to persuade it.

Being developed from a case study, the new probabilistic model also predicts an estimation of a sales potential. The model has set the parameter λ of the Huff model to combine the concept from the theory, the Converse's modified gravitation.

The new probabilistic model was tested at the city of Daejeon (Youn et al., 2007), and λ had 1 of denominator and 4 of numerators to estimate probability as well as estimated sales potential.

Converse's law of the modified retail gravitation (Converse, 1949) is used to estimate a breaking point of market area in connection with the population of the market area. Then it is use to calculates a total expenditure of consumption in a pertinent area. The method of the study supplements the limitation of the precedent case studies by remarkably reducing probabilistic errors.

Table 1. Probability depending upon size of each store.

Store No.	S_j	T_{ij}	$S_j/(T_{ij}^2)$	$n\sum(i=1)\{S_j/(T_{ij}^2)\}$	P_{ij} (%)	The range of fluctuation (%)
1	10	10	0.1000	0.1000	1.82	
2	20	10	0.2000	0.3000	3.64	1.82
3	30	10	0.3000	0.6000	5.45	
4	40	10	0.4000	1.0000	7.27	1.82
5	50	10	0.5000	1.5000	9.09	
6	60	10	0.6000	2.1000	10.91	1.82
7	70	10	0.7000	2.8000	12.73	
8	80	10	0.8000	3.6000	14.55	1.82
9	90	10	0.9000	4.5000	16.36	
10	100	10	1.0000	5.5000	18.18	1.82
Total					100	

Table 2. Probability depending upon travel time.

Store No.	S_j	T_{ij}	$S_j/(T_{ij}^2)$	$n\sum(i=1)\{S_j/(T_{ij}^2)\}$	P_{ij}	The range of fluctuation (%)
1	10	10	0.1000	0.1000	64.53	
2	10	20	0.2050	0.1250	16.13	48.4
3	10	30	0.0111	0.1361	7.17	
4	10	40	0.0063	01424	4.03	3.14
5	10	50	0.0040	0.1464	2.58	
6	10	60	0.0028	0.1491	1.79	0.79
7	10	70	0.0020	0.1512	1.32	
8	10	80	0.0016	0.1527	1.01	0.31
9	10	90	0.0012	0.1540	0.79	
10	10	100	0.0010	0.1550	0.65	0.15
Total					100	

Table 3. New probabilistic model-probability depending upon changes of travel time.

Store No.	S_j	T_{ij}	$S_j/(T_{ij}\times4)$	$n\sum(i=1)\{S_j/(T_{ij}\times1)\}$	P_{ij} (%)	The range of fluctuation (%)
1	10	10	0.2500	1.0000	8.54	
2	10	20	0.1250	1.5000	4.27	4.27
3	10	30	0.0833	1.8333	2.85	
4	10	40	0.0625	2.0833	2.13	0.71
5	10	50	0.0500	2.2833	1.71	
6	10	60	0.0417	2.4500	1.42	0.28
7	10	70	0.0357	2.5929	1.22	
8	10	80	0.0313	2.7129	1.07	0.15
9	10	90	0.0278	2.8290	0.95	
10	10	100	0.0250	2.9290	0.85	0.09
Total					25.01	

The findings vary upon changes of travel time of the new probabilistic model under the same conditions as precedent tests. λ is set by using the precedent test values.

In Table 3, T_{ij} increases each 10 from 10 to 100. P_{ij} of No.1 store is 8.54% which is the highest, followed by 4.27% of that of No.2 store, and the range of fluctuation among stores is 4.27%.

The new probabilistic model has less range of fluctuation than does Huff model, and λ applied the same

Table 4. Probability value and estimated sales of each model.

Name of stores	Actual sales (A)	Estimated sales (B)		Probability value		Error ratio (B/A)	
		Huff model (%)	New probability (%)	Huff model (%)	New probability (%)	Huff model (%)	New probability (%)
D company's HQ				32.3	8.43		
D company's Jungang branch	2,064	1,997	510	9.8	2.32	3.24	75.29
L company's Daejeon branch	2,323	1,793	422	37.8	8.9	22.8	81.82
S department store	357	954	254	20.1	5.35	167.11	28.9
Total	4,744	4,744	1,186	100	25	193	186

(Unit: 100mil. Won)

as in the precedent case studies is no more than an estimate by experience.

The aggregation of all of the stores P_{ij} accounts for 25%, considering the existing Huff model that estimated probability to visit each store is subject to 100% of total market, all of the values are greatly lowered to make errors. This fact, however, is thought to contribute to the related academic circle because of its accommodation of all the businesses.

The existing models may have no problems to apply into an actual operation for investigating sales potentials when a new store opens, but they have problems which have not been addressed enough to define them clearly and tested by analysis techniques.

The target area set by the present study is the city of Daejeon, and the data collected in 2005 are used. In details, the study employs four large department stores, and firstly investigates actual sales volume of each store. Then the basic data such as size, distance and others are inputted to analyze, and they are compared with the results.

CASE STUDY

The numbers of the total stores were 17,000 in the city of Daejeon in 2005 (see the Daejeon municipal governmental report), and the total sales volume of all the retail markets that year accounted for 4 trillion 447 billion and 200 million Won. Four department stores are chosen mainly due to the fact that there were only the four department stores. The sum of the sales volume based on the financial statement of each department store was about 5 trillion 136 billion Won. The sum of the sales volume statement also included sales that were made from leasing business and other affiliated businesses. Net sales volume of goods made from all the department stores excluded the leasing business and others were about 4 trillion 744 billion Won.

Table 4 shows probability value and estimated sales of each department store by surveyed. The travel time of

each department store is measured by using a vehicle from the following five downtown locations: Shintanjin Station, Seodaejeon Sageori, Daejeon Station, Daejeon City Hall, and Yuseong Sageori. The average value of travel time is achieved through dividing the travel time by the number of the downtown locations.

At the Huff model, D company earn 199.7 billion Won of sales with 3.24% of errors in the actual sales, and L company has 179.3 billion Won of sales with 22.8% of errors, and S company has 95.4 billion Won of sales with 167.11% of errors.

At the new probabilistic model, however, D company obtains 51 billion Won of sales with 75.29% of errors, and 42.2 billion Won of sales with 81.82% of errors to L company, and 25.4 billion Won of sales with 28.9% of errors to S company.

Total error ratio of both the Huff model and the new probabilistic model is 193 and 186 each, revealing lower at the new probabilistic model. Difference in actual sales is 119.4 billion Won and 355.8 billion Won each, indicating a great deal of difference at the new probabilistic model.

The Huff model has a fixed value of λ to be likely inclined to one side depending greatly upon analysis situation, while the new probabilistic model may produce errors of changes from all of the probability values with different substitution of denominator and numerator of λ. Variables are set to establish a model to estimate sales potential with these following conditions:

1) The variables are set to have their own value. The sales as variable cannot be described by fixed variable, so the value of variables should set through marketing research by situation. The factor, distance, can be set in accordance with the square formula to produce varied values, but it is the same value within the same distance.

2) The variables do not have influence upon all the probability values. When the numerator is applied with each variable value as in the precedent case studies, all of the probability values may fluctuate to produce errors of basic formula that has estimated probability to visit

Table 5. General Information on the subjects.

Gender		Males 32 (31.2)	Females 70 (68.8)	Total 102 (100)
Age	20~30	8(7.84)	21(20.59)	29(28.43)
	31~40	12(11.61)	25(24.67)	37(36.27)
	41~50	10(9.80)	21(20.59)	31(30.39)
	51~	2(1.96)	3(2.94)	5(4.90)
	Total	32(31.22)	70(68.78)	102(100)
	~ 1	-	-	-
	1~2	5(4.90)	26(25.49)	31(30.39)
Monthly income	2~3	14(13.73)	22(21.57)	36(35.29)
(Unit : 1mil won)	3~4	11(10.78)	17(16.67)	28(27.45)
	4 ~	2(1.96)	5(4.90)	7(6.86)
	Total	32(31.37)	70(68.63)	102(100)

Number of the respondents (%).

Table 6. Comparison of estimated sales of each model.

Name of Stores	Actual sales (A)	Estimated sales (B)		Probability value		Error ratio (B/A)	
		Huff model (%)	New probability (%)	Huff model (%)	New probability (%)	Huff model (%)	New probability (%)
D company's Headquarters	2,064	1,997	510	1,952	324	7529	5.41
D company's Jungang branch							
L company's Daejeon branch	2,323	1,793	422	2,202	22.8	81.82	5.22
S department store	357	954	254	590	167.11	28.9	6525
Total	4,744	4,744	1,186	4,744	193	186	76

(Unit: 100 million Won).

each store based on all of the values. Therefore, relative application of the variables to each store cannot have influence on all of the values, meaning that the aggregation of the probability of all of the markets will always keep 100% in spite of the variables.

3) The variables have an application time. The variables reflect a market environment that changes from time to time so that not only survey time but also analysis time is properly considered.

4) The variables have to be converted into an exact value to calculate. This study, therefore, seeks to get effective findings on the condition upon which the variable values do not have influence upon all of the probabilities. With the conditions, a new research model (formulation) is established for the current study.

Based on the Reilly's theory that the probability of the visit is in inverse proportion to distance, David Huff set a variable, T_{ij}^{λ}, which impact on distance (Huff, 1963). The new probabilistic model has set 1 of denominator and 4 of numerators of T_{ij} of λ, where P_{ij} is always fixed. The concept that resetting of the model is in inverse proportion to distance is not be adopted. Instead, factors having influence upon distance and travel time are going to be set as λ as in the new probabilistic model. The factors are expected to be effective to apply analysis value not into the fixed value but the market survey value in analysis time.

This study measures variables from an actual market survey and adopts the new probabilistic model to inspect existing research cases.

Upon the establishment of a new store, a variety of factors are indeed involved in market area analysis and its associated estimation of a sales volume. Those fac-tors lie within regional, economic and social realms. It is very much difficult to analyze all of these factors. It is not useful to use the materials that explain these factors. The scope of the analysis, therefore, has been mostly limited.

Kim (1999) reports that the number of employees, area of the stores, and area of the warehouse play important roles in sales performance, except location and prices. But other factors (that is, markets, assortment of the products, and recognition on each store, and etc.) also have to be extensively put into consideration.

Of all the variables, this study selects variables that are expected only to have a significant impact on the efficiency of differentiation of a store. To inform consumers with the efficiency of differentiation, stores may strive to make efforts to do public relations and use promotion strategies, so consumers in a market area are much likely to visit the stores and to buy goods. Thus, advertising and sales promotion expenses are considered in the present study.

Consumers' recognition on each department store is also selected to be a variable. As David (2006) argues, top-of-mind brand recognition can have influence upon the visit to either its stores or competing stores among consumers in a market area. The variable here is closely measured by consumers' top-of-mind brand recognition on department store brands along with other aided awareness on each department store.

Both advertising expense and sale promotion expense are investigated by using the financial statements of each store. The expense of 'L' company is achieved by dividing a total expense by number of the stores because the total expense of the stores, only of all, can be released from the financial statements.

The Advertising expenses are relatively large. 10.3 billion Won of 'D' company stands first, 5.5 billion Won of 'L' company, and about 2.1 billion Won of 'S' company, while the sales promotion expense in order is 10.3 billion Won of 'L' company and 3.4 billion Won of 'S' company. 'D' company has had no account of sales promotion expense at the income statement, which is presumably to be included in the advertising expense of the company.

A survey was conducted in November 11, 2008 to investigate consumers' recognition on each department store in Daejeon. 102 copies of the questionnaire for the survey have been given to each subject. Table 5 shows the subjects' general information ranging from gender, age, and household income. All the subjects are over 20-year-old males and females, consisting of 32 men (31.22%) and 70 women (68.78%). The ages between 31 and 40 occupy the most (36.27%), followed by 41~50 years old (30.39%), 20~30 years old (28.43%), and 51 years old or more (4.9%) in order. Monthly household income in order are; the income of

2 million to less than 3 million Won occupied the most (36 persons, 35.29%), followed by 31 persons of 1 million to less than 2 million Won (30.39%), 28 persons of 3 million to less than 4 million Won (27.45%), and 7 persons of more than 4 million Won (6.86%).

Top-of-mind brand recognition (see Aaker, 2006) is the highest with 'D' company (49.02%), followed by 'L' company (45.10%) and 'S' company (5.88%) in order. The aided, which is the percent of respondents who say they saw

any advertisements for a specific product or brand, is high in order of 'L' company (97.06%), 'D' company (95.10%) and 'S' company (87.25%). And, the experience of the use of department stores is high in order of 'L' company (76.47%), 'D' company (73.53%), and 'S' company (35.29%). The experience of the use also includes the response which is not buying experience, but simple experience of the use that has no influence upon sales of the goods. The experience was investigated to exclude poor reply comparing with aided awareness to adopt top-of-mind (TOM) only as a variable that could be general decision criterion of actual market share.

Higher advertising expense, sales promotion expense, and top-of-mind store brand recognition come out as important variables affecting success in frequent visits of a store to raise sales in the city of Daejeon.

Through the following formula, the value of each variable is obtained. Like the concept of the probability model, a diagram having positive (+) relations is made to compute a high ratio at a high individual value. The mathematical formula is as follows:

$$V_j = G_j / n\sum(j=1) \, G_j$$

where V_j is ratio of expenditure of advertising expense as well as sales promotion expense at the store j of market area, G_j is advertising expense and sales promotion expense of the store j, n is number of the stores.

From the formula, the higher advertising expense, sales promotion expense and brand cognition on the store, the higher result values to have positive influence upon not only size and time factor of the stores but also the sales. Therefore, the stores that have a proportionally high value at all of the markets can be influenced on the sales as much as these weights.

The sales volume of the Huff model and the new probabilistic model with the variables applied in the previous research is compared with the sales volume calculated by the new model which applied to the variables measured newly in new probability model. The new probability (①) in Table 6 is the model that is applied to the variables of the precedent studies which was designed by Youn et al. (2007). The ② is the model that is done to the variables analyzed by this study. The findings are shown in Table 6.

In Table 6, the sales volume for D company based on ② accounts for 195.2 billion Won, 220.2 billion Won of L company, and 59 billion Won of S Company, and the error ratio of each company is 5.41, 5.22 and 65.25%, respectively. The total error ratio is 193% of the Huff model, 186% of the ① and 76% of the ②. Therefore, the total error ratio of the ② is 117% lower than that of the Huff model, and 110% lower than that of the ① to be the closest to the actual sales.

The outcome of the ② is the closest to the actual values among that of the existing models. From this study,

such factors as advertising expense, sales promotion expense and top-of-mind store brand recognition have been found to impact convincingly on actual sales.

At the present in which the sales volume of all of the market could be looked at, the sale volume of S department store lowered remarkably considering its size and distance. In other word, its sales could be partially absorbed by not only 'D' company but also 'L' company as the result.

In fact, the sales volume of S company accounted for 137.8 billion Won in 2002 and decreased rapidly down to 43.1 billion Won in 2003. This is because both the internal factors (that is, assortments of commodities, prices, and services) and the external factors (e.g., economic crisis, reducing real income, and decreasing consumption) which have influence upon sales volume. However, these various kinds of special situations are not considered in this study.

CONCLUSION

At the Department store in Korea, the Huff model of theories for commercial district analysis is best suited by the tukjeongmeip system (Korean Style Consignment), which is the way that the department store first purchases on credit goods from the vendors and goods in stock are returned after selling them. Therefore, this study tries to derive the results through extending the Huff model. This study examines the existing theoretical models to see whether or not the existing models can predict sales potential in a precise manner particularly associated with a mid-sized local city in Korea. The present study realizes that the precedent models have seldom predicted an estimation of sales potentials at the opening of stores especially at local markets and that the existing models did not offer specific factors affecting success in estimating a sales volume at the point of opening in local markets in Korea. The followings are the findings of the current study in details:

1. When there are a lot of competing stores particularly at a mid-sized market area in Korea, the range of error of the Huff model is likely to increase greatly.
2. As in the precedent studies, when the new probabilistic model differently sets variables for denominator and numerator, all the probability values change. As a result, the basic principle that has calculated probability values of each individual store based on all of the markets became errors.
3. The sales volume that the existing models have calculated is difficult to describe the fluctuations of the sales. Based on the analyses above, conditions of variables should be made. And, variables should have no influence upon all of the probability values.
4. To measure variables proportionally, a formula is set to make a diagram in positive (+) relations.

5. The variables measured in this study are advertising expense, sales promotion expense, and top-of-mind store brand recognition. The findings from the diagram are as follows: not only 'D' company but also 'L' company has had about 5% of the error ratio comparing to their actual sales volumes, while the market area in this study has had as high as 76% of the total error ratio. Therefore, the range of the errors of this study is greatly reduced compared to that of the Huff model or the other precedent studies. The factors suggested here are advertising expense, sales promotion expense, and top-of-mind store brand recognition on the four large department stores play pivotal roles in increasing the sales volume at the inceptive business stage.

Thus, the findings contribute to both studies of setting more developed models and studies of distribution industry in local markets in the Eastern Asia region. The current study, however, has some of limitations. First, it is the subjects of this study: that is, they are all of the large-sized retail stores at Daejeon. One main reason for the selection of the large retail stores is an easy availability of their financial statements as raw data. Lastly, the findings are the new model estimating sales for the large sized retail stores in the city and the main factors affecting success in the stores' sales at its inceptive stage. But direct or indirect impact factors are not used enough. It is further suggested in this study that developing more delicate estimation model of the sales be needed to apply it to the realties of the specific local levels in such East Asian countries as China, Korea, and Japan in the future. Along with that, various kinds of impact factors are used to investigate cases enough and to make base of investigation process. In addition, the reason that the presented model still has high error rate is due to the existence of other variables excluding a shop area and turnover time.

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