Constructing the Markov Chain Model with Covariates to Forecast the Change of Consumer Shop-around Movements Caused by the Redevelopment of Hang Da Market in Hanoi, Vietnam

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Abstract

Since 2007, the People's Committee of Hanoi (PCH) has begun launching an ambitious plan aiming to improve and upgrade the retail facilities across Hanoi city, especially regarding the system of traditional markets. The system of more than 126 traditional markets will be redeveloped in the coming years across Hanoi city, including three big markets in the city center commercial district (CCCD) of Hanoi. However, Hanoi urban managers seem to face difficulties in finding a scientific method to assess the effects of the redevelopment projects of traditional markets for planning the system of retail facilities.

For the purpose, a method using the Markov chain model with covariates which was introduced by Saito and Ishibashi (1992), is considered as a promising method to assess

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the effectiveness of retail redevelopment projects for planning the spatial structure of City Center Retail Environment (CCRE) since it can predict the change of the agglomeration effects on each shopping node caused by the change of locational arrangements of retail facilities in the shopping district. Their model, however, has yet to be applied fully to developing countries.

With the aim of seeking an appropriate method to evaluate the effects of the redevelopment projects of traditional markets in Hanoi, in this paper, we try to apply the Markov chain model with covariates to forecast the changes of consumer shop-around movements after Hang Da Market is redeveloped. By comparing the forecasted results of this method with the estimates by using the consistent OD (Origin Destination) density estimation method, we realized that the forecasted results show the significant accuracy enough to prove the applicability and efficacy of the shop-around Markov model in planning or making feasible projects in Hanoi, Vietnam.

Key words : City center commercial district (CCCD), City center retail environment (CCRE), Hanoi, Hang Da Market, Markov chain, Shop-around behavior.

1. Introduction

Since 2007, the People's Committee of Hanoi (PCH) has begun launching an ambitious plan to improve and upgrade the retail facilities across Hanoi city, especially regarding the system of traditional market. A system of more than 126 traditional markets will be redeveloped in the coming years across Hanoi city including three big markets in the city center commercial district (CCCD) of Hanoi. In 2007, Hanoi has implemented 27 projects of traditional market redevelopment with the total investment of about 2,000 billion Vietnam dong (VND[1]). The first market redeveloped in the CCCD was Hang Da Market. It was completed and put into operation in October, 2010. The new Hang Da Market is a 5-story building and two story basements with 17,530m^2 total

[1] Exchage Rate : 1USD＝16,100VND (as of January, 2007)

shopping floor area, comprising approximately 10,000m^2 of modern retail space and 7,530m^2 for a traditional market. After Hang Da Market, redevelopments of Dong Xuan and Hang Be Markets have been scheduled as next plans. By modernizing the current traditional market system, these redeveloped traditional markets are expected to keep the course of sustainable growth.

However, Hanoi urban managers seem to face difficulties in finding a scientific method to assess how Hanoi consumers are affected by the redevelopment projects of traditional markets and how those redevelopment projects enhance Hanoi consumers' welfare. In order to solve these matters, in a previous study, we have already proposed a method that is based on the analysis of the micro behavioral changes in consumer shopping behaviors and enables to assess the aggregate effects of traditional market redevelopment by employing the consistent OD (Origin Destination) estimation method (Cf. [20]). However, this method is only seen as an ex-post evaluation method, while an ex-ante evaluation also is considered quite important for planning redevelopment projects.

Therefore, while we are seeking for a possibility to use the consistent OD estimation method for forecasting, here we use a different method from the consistent OD estimation method to estimate and forecast the effects of retail redevelopment projects from the viewpoint of consumer shop-around behaviors. The method, which we would like to use in this study, is the Markov chain model with covariates due to Saito and Ishibashi (1992).

Markov chains, a special type of stochastic processes, have been applied to many areas such as education, marketing, health service, finance, production, and reliability analysis. Applications of Markov chains to consumer shop-around behaviors have attracted many researchers in recent years. These researches have begun and developed since 1980s. The significant researches are an absorbing Markov chain model by Saito (1983) and Sakamoto (1984), a Markov chain

model with covariates to forecast consumer shopping trip chains by Saito and Ishibashi (1992), a choice-based Poisson regression model integrated with Markov shop-around model to evaluate city center retail redevelopment by Saito, et al (1996), and a fusion of a Huff model and a Markov chain model by Yokoi, et al. (2000) and so on.

We follow the Markov chain model with covariates due to Saito and Ishibashi (1992) in this research. For the first time, Saito (1983) used a stationary absorbing Markov chain model to account for consumer shop-around behaviors within a shopping district. In general, the model can be understood as follows. A person visits to several shopping nodes in a shopping district for his shopping purposes. This one is called a shop-around trip chain or shop-around movements. In this model, consumer's shop-around trip chain is described as an infinite process of an absorbing stationary Markov chain. Thus its stochastic process is dealt with as the standard modeling procedure of Markov chain. The model specifies several types of nodes in a shopping district and describes consumer's shop-around trip chain as a cycle on these nodes. The cycle is treated as the sequence composed of the OD pairs formed by all two consecutive nodes in the cycle. All the OD pairs are regarded as unlinked OD trips and aggregated into the observed OD flows matrix of consumers who shop-around within a shopping district. Then the observed OD flows matrix is transformed into an observed transition probability matrix among shopping nodes. Its two sub-matrices of observed transition probabilities are explained by logit models with two usual covariates of time distance between shopping nodes and shopping floor spaces of nodes. These two sub-matrices of transition probabilities are integrated into an absorbing stationary Markov chain model with covariates, which can forecast the change of total visits to each shopping node when covariates change.

This method is considered as a promising method to assess the effectiveness of retail redevelopment projects for planning the spatial structure of CCRE since it can predict the change of the agglomeration effects on each shopping node caused by the change of locational arrangements of retail facilities in the shopping district.

In this paper, we try to apply the Markov chain model with covariates to forecast the changes of consumer shop-around movements after Hang Da Market is redeveloped. Fortunately, we have two on-site survey data of consumer shop-around behaviors at two points of time, i.e., before and after the redevelopment of Hang Da Market (2004 and 2011). Therefore, based on the survey data in 2004 we can forecast forward the numbers of consumers who visit the CCCD in 2011 after the redevelopment of Hang Da Market. Conversely, we can forecast backward from the survey data in 2011 the number of consumers who visited the CCCD in 2004. From these forecasted results we can assess the degree of accuracy of forecasting model by comparing them with the observation data and the estimates of the consistent OD estimation method at the same point of time.

2. The Markov chain model with covariates to forecast consumer shop-around behaviors in a commercial district

The previous researches such as Saito in 1983, Sakamoto in 1984, Saito and Ishibashi in 1992 provided the foundation for applying the Markov chain model to analyze consumer shop-around behaviors. Saito (1983) first presented an absorbing Markov chain model that enables one to expess the estimation formula to calculate consumer shop-around effects on each shopping district. Saito and Ishibashi (1992) further provided a Markov chain model with covariates to forecast consumer shop-around behaviors within a city center commercial district.

Saito and Ishibashi (1992) also indicated that the shop-around effect to each shopping node is the expected number of visits contributed by the consumer shop-around behaviors, or equivalently, the expected number of consumer visits to each shopping node after having visited other shopping nodes. By the definition, the shop-around effect is the visits to each shop node after the first step, i.e., n $\geq$2 so that the shop-around effect denoted by *RE* can be formulated as follows :

$$\begin{aligned} RE &= F_{HoH}P_{HI}P_{II} + F_{HoH}P_{HI}P_{II}^2 + F_{HoH}P_{HI}P_{II}^3 + \ldots \\ RE &= F_{HoH}P_{HI}P_{II}(I - P_{II})^{-1} \end{aligned} \tag{2.1}$$

The total visits to each shop node can be expressed as follows :

$$\begin{aligned} \text{Total visits} &= F_{HoH}P_{HI} + F_{HoH}P_{HI}P_{II} + F_{HoH}P_{HI}P_{II}^2 + F_{HoH}P_{HI}P_{II}^3 + \ldots \\ &= F_{HoH}P_{HI}(I - P_{II})^{-1} \\ &= F_{HoH}P_{HI} + RE \end{aligned} \tag{2.2}$$

Here P_{HI} represents entrance probabilities from the entry nodes to shopping nodes. P_{II} expresses the shop-around probabilities among the shopping nodes. F_{HoH} represents the numbers of consumers who get into a central commercial district from home to the entry nodes. In order to understand more clearly, readers are referred to the references of [21] and [22].

Base on the formulation of (2.2), Saito and Ishibashi have explained the transition probabilities of P_{HI} and P_{II} by some covariates so that the changes of the shop-around effects can be predicted. More specifically, they have used a multinomial logit model to explain the correlation between some covariates representing retail environment facilities and choice probabilities of shopping nodes given either an entry node (P_{HI}) or a shopping node (P'_{II}). P'_{II} is a probability matrix which is obtained from concatenating horizontally two matrices of P_{II} and P_{IH}. This can be understood that a shopper after stopping at a shopping

node he will choose either going to other shopping node or going back home. Thus if we find some changes of retail environment facilities such as shopping floor space, time distance from entry node to shopping node, from this shopping node to other shopping node and so on, we are able to estimate the change of P'_{II} and P_{HI}. Then from the formulation (2.2), we fully forecast the change of consumer shop-around movements.

3. Methodology and survey data

3.1. Methodology

In this study, we would like to use the Markov chain model with covariates to forecast the changes of consumer shop-around movements after Hang Da Market is redeveloped. Fortunately, we have two on-site survey data of consumer shop-around behaviors at two points of time, i.e., before and after the redevelopment of Hang Da Market (2004 and 2011). Therefore, based on the survey data in 2004 we can forecast forward the numbers of consumers who visit the CCCD in 2011 after the redevelopment of Hang Da Market. Conversely, we can forecast backward from the survey data in 2011 the numbers of consumers who visited the CCCD in 2004. The first calculation is called an analysis of forward forecast and the other way is an analysis of backward forecast. Figure 1 and Figure 2 show specifically the process of two calculations.

In this study, the CCCD of Hanoi is considered as a shopping district system including 25 shopping nodes. The definition of 25 shopping nodes was described in Figure 3. The entry node and exit node are denoted by 26 and go home by 27.

According to the process of calculating, after collecting all inputdata needed, we need to formulate the shop-around Markov model, i.e., the shop-around structure

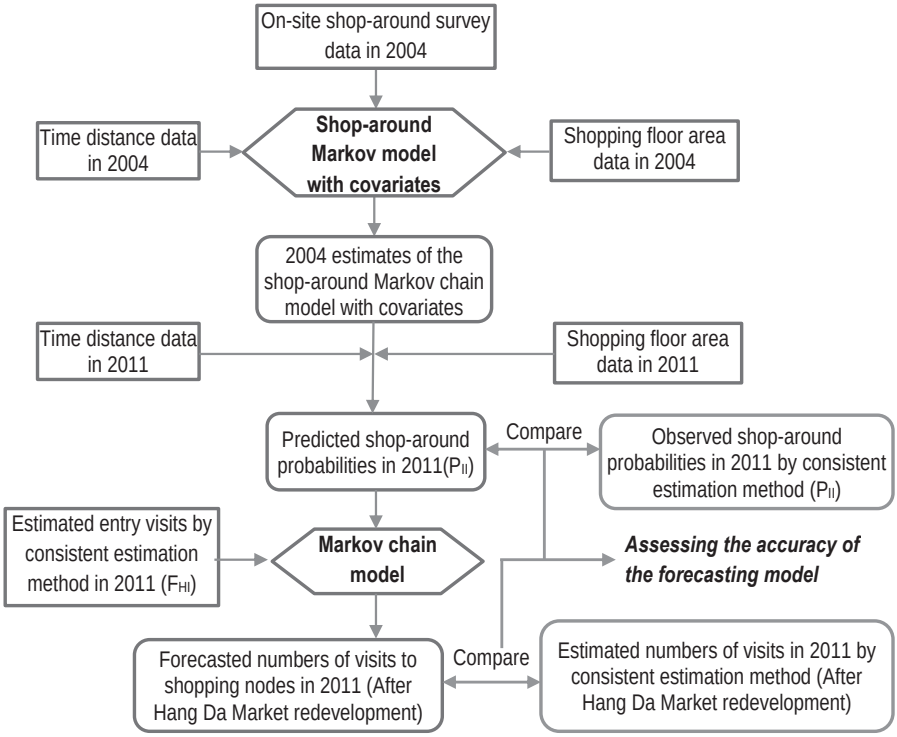


Figure 1 Process of the forward forecasting analysis

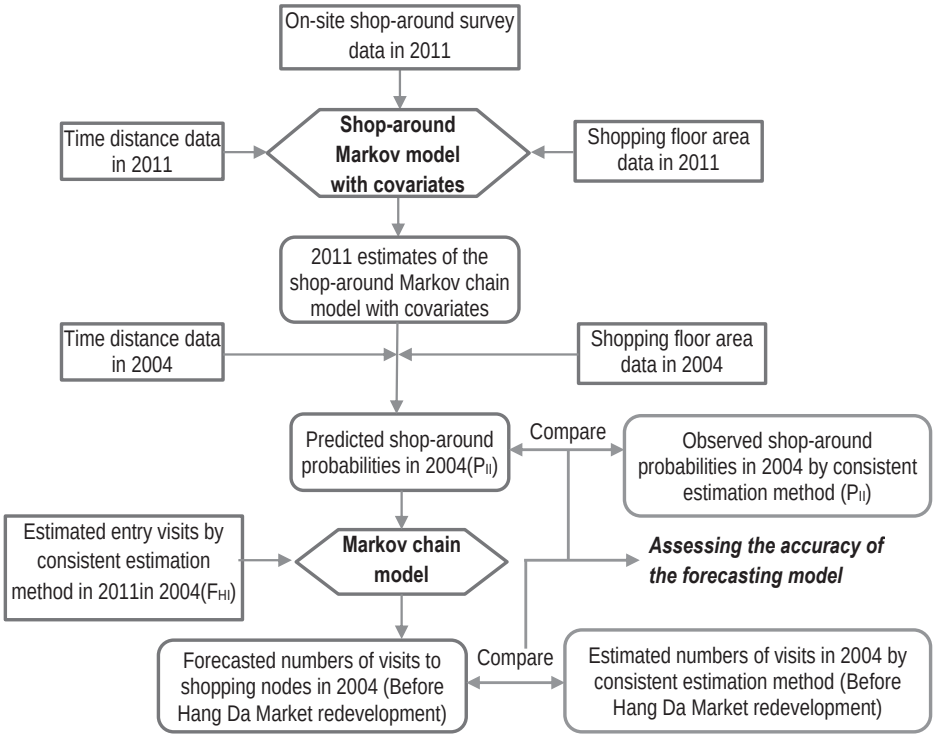
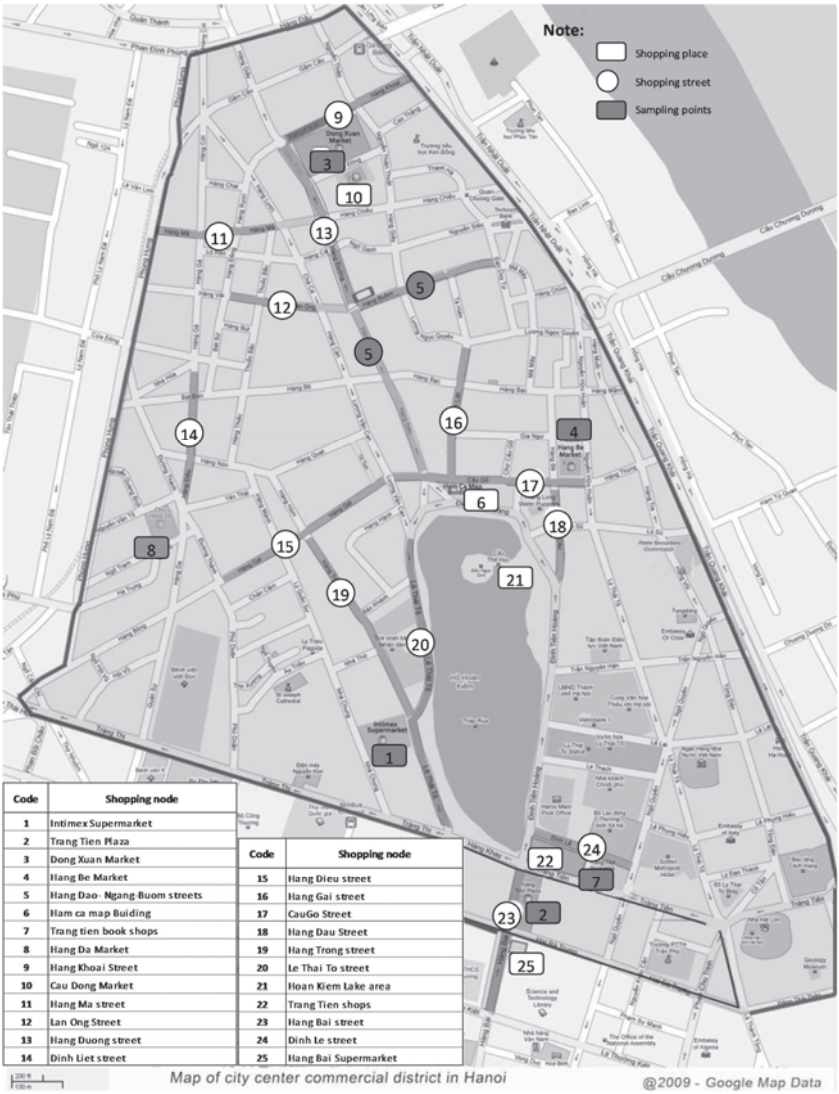


Figure 2　Process of the backward forecasting analysis



Code	Shopping node
1	Intimex Supermarket
2	Trang Tien Plaza
3	Dong Xuan Market
4	Hang Be Market
5	Hang Dao- Ngang-Buom streets
6	Ham ca map Buiding
7	Trang tien book shops
8	Hang Da Market
9	Hang Khoai Street
10	Cau Dong Market
11	Hang Ma street
12	Lan Ong Street
13	Hang Duong street
14	Dinh Liet street

Code	Shopping node
15	Hang Dieu street
16	Hang Gai street
17	CauGo Street
18	Hang Dau Street
19	Hang Trong street
20	Le Thai To street
21	Hoan Kiem Lake area
22	Trang Tien shops
23	Hang Bai street
24	Dinh Le street
25	Hang Bai Supermarket

Figure 3 Map of shopping nodes in the CCCD of Hanoi

model, for the CCCD of Hanoi including 25 shopping nodes. We note that we have only formulated the shop-around structure model to forecast the changes of shop-around visits. The entry structure model has not been constructed yet. From this reason, we temporarily use the observed frequency distribution of entry visits for the estimates of P_{HI} and F_{HoH} at two points of time, i.e., the survey data in 2004 and 2011. In fact, while we collapsed the node sets of H_0 and H, we applied the consistent estimation method to obtain the estimate for the observed frequency distribution of entry visits. For more details, readers are referred to the references of [19] and [20].

Next, we estimate the shop-around effects of Hang Da Market redevelopment by using the formulation (2.1) in Markov chain model at two points of time, after and before the redevelopment of Hang Da Market.

Finally, we try to assess the accuracy of the forecasting model by comparing the predicted shop-around probabilities with observed ones as well as the forecasted numbers of visits with the estimated number of visits obtained by the consistent OD estimation method at the same point of time.

3.2. Survey data

The data used in this study are obtained from two on-site surveys at the CCCD of Hanoi in 2004 and 2011. The outline of these surveys was described in the previous studies (Cf. [19], [20]). A total of 913 samples were collected from the first survey and 600 samples from the second survey. The major data used in this research is consumer shop-around trip chain data. To obtain this data, the respondents were asked to record all the history of their activities in the CCCD of Hanoi. The recorded history of their trip chain is expressed as a sequence of triples composed of nodes to stop at, the purposes done there and expenses spent

there in the order of their occurrence. In order to look at the trip chains of all consumers in the (matrix or table) form of how many consumers move from which node to which, we must make a trick to decompose a trip chain into the set of all "unlinked" trips between two consecutive nodes contained in the chain.

We explain this below. First consider the sequence of all stops in the trip chain of a consumer. We decompose the sequence into the set of all consecutive pairs of stops contained in the sequence. Every consecutive pair of stops in the trip chain, say, stops at shopping node i and j, is recorded as a count of movements from shopping node i to node j. If we sum up every respondent's trip chain in this way, we obtain a frequency table of shop-around movements of all the respondents among all shopping nodes. These shop-around movements between two consecutive shopping nodes in all trip chains are treated as independent "unlink" trips. The results are shown in Table 1 and Table 2.

Apart from using the trip chain data from the on-site shop-around survey, we also investigate and collect the information of CCRE of Hanoi such as shopping floor spaces of shopping nodes, time walking distances among shopping nodes, and especially the information of Hang Da Market at two points of time, before and after its redevelopment. In this study, we assume that the time distance does not change between two points of time, before and after Hang Da Market redevelopment. The collected data are shown in Table 3 and Table 4.

4. Formulating the shop-around Markov model of Hanoi CCCD

The choice of retail store's location and size is one of most important decisions for city planners and retailers to make before building or redeveloping a retail store (Craig et al., 1984). Therefore, planners need a method to evaluate to what

Table 1 Observed shop-around movements obtained from survey data in 2004

From \ To			I																								H	Sum
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25		
Intimex Supermarket	I	1	159	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	3	18	0	0	5	0	100	289
Trang Tien Plaza	I	2	0	136	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	4	10	7	1	27	81	280
Dong Xuan Market	I	3	0	0	161	0	0	0	0	0	0	41	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	88	294
Hang Be Market	I	4	0	0	0	192	0	17	0	0	0	0	0	0	0	0	0	0	31	7	0	0	7	0	0	0	0	97	351
Hang Dao-Ngang-Buom streets	I	5	0	1	18	6	289	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	131	445
Ham ca Map Building	I	6	0	0	0	16	0	96	0	0	0	0	0	0	0	0	0	12	9	0	0	0	29	0	0	0	0	69	231
Trang Tien bookshop	I	7	2	20	0	0	0	0	110	0	0	0	0	0	0	0	0	0	0	0	0	0	16	54	0	29	0	78	309
Hang Da Market	I	8	2	0	0	1	2	3	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	2	14
Hang Khoai street	I	9	0	0	8	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Cau Dong Market	I	10	0	0	33	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41	94
Hang Ma street	I	11	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Lan Ong street	I	12	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Hang Duong street	I	13	0	0	12	0	0	0	0	0	8	2	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	4	31
Hang Dieu street	I	14	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Hang Gai street	I	15	0	0	0	7	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
Dinh Liet street	I	16	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	7	0	0	0	1	0	0	0	0	14	24
Cau Go street	I	17	0	1	0	29	0	31	0	2	0	0	0	0	0	0	0	3	14	0	0	0	0	0	0	0	0	30	110
Hang Dau street	I	18	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	12
Hang Trong street	I	19	7	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Le Thai To street	I	20	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	3	20
Hoan Kiem Lake area	I	21	5	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	0	5	0	89	104
Trang Tien Shops	I	22	1	3	0	0	0	0	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	2	0	41	95
Hang Bai street	I	23	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	6	16
Dinh Le street	I	24	6	1	0	0	0	0	32	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	0	6	0	19	74
Hang Bai Supermarket	I	25	0	12	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	12	1	1	0	0	13	50
Entry visits		H	94	96	60	91	145	81	96	10	7	24	2	1	22	2	10	9	45	5	15	14	12	15	8	26	23	0	913
Total			289	280	294	351	445	231	309	14	15	94	2	2	31	2	12	24	110	12	15	20	104	95	16	74	50	913	

Table 2 Observed shop-around movements obtained from survey data in 2011

From \ To			I																								H	Sum
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25		
Intimex Supermarket		1	69	1	0	2	1	4	3	5	0	0	2	0	1	0	1	0	0	0	4	9	13	2	0	1	0	34	152
Trang Tien Plaza		2	7	110	0	1	1	1	10	4	0	1	0	0	0	0	0	0	0	0	0	0	12	3	0	0	15	71	236
Dong Xuan Market		3	0	2	138	0	14	1	2	1	16	28	5	4	9	2	0	0	4	0	0	0	1	0	0	0	0	40	267
Hang Be Market		4	0	0	0	48	36	2	2	1	0	1	0	0	2	0	0	1	1	3	0	0	6	0	0	2	0	38	143
Hang Dao-Ngang-Buom streets		5	5	0	5	35	131	19	0	18	4	8	8	1	18	0	1	1	12	9	0	0	8	2	0	3	0	69	357
Ham ca Map Building		6	3	2	1	4	21	6	2	3	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	33	78
Trang Tien bookshop		7	8	10	0	1	2	2	27	2	0	0	0	0	0	0	0	0	0	3	0	0	22	14	0	5	6	29	131
Hang Da Market		8	1	0	1	0	8	2	0	76	0	2	6	1	3	17	15	0	0	0	5	1	4	0	0	0	0	69	211
Hang Khoai street		9	0	0	9	0	0	1	0	2	1	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	40
Cau Dong Market		10	0	0	38	0	3	0	0	1	4	7	0	0	4	0	0	0	1	0	0	0	0	0	0	0	0	15	73
Hang Ma street		11	0	0	4	0	5	1	0	4	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	11	26
Lan Ong street		12	0	0	1	0	2	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	2	8
Hang Duong street	I	13	0	0	19	1	7	0	0	2	3	6	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	16	60
Hang Dieu street		14	1	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	31
Hang Gai street		15	0	0	0	0	1	0	0	3	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	15	22
Dinh Liet street		16	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Cau Go street		17	0	0	0	3	1	0	0	1	0	0	0	0	1	0	0	0	1	3	0	0	1	0	0	0	0	17	28
Hang Dau street		18	0	0	0	1	2	5	0	0	0	0	0	0	0	0	0	0	2	0	0	0	8	0	0	0	0	5	23
Hang Trong street		19	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	2	10
Le Thai To street		20	3	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	1	15
Hoan Kiem Lake area		21	12	8	0	5	6	3	15	0	0	0	0	0	0	0	0	0	0	3	0	0	15	8	0	1	0	82	158
Trang Tien Shops		22	2	10	0	0	1	0	19	1	0	0	0	0	0	0	0	0	0	0	0	0	7	14	0	2	0	7	63
Hang Bai street		23	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Dinh Le street		24	1	3	0	5	3	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	12	0	3	42
Hang Bai Supermarket		25	3	15	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	3	3	30
Entry visits		**H**	36	74	51	37	111	30	35	73	11	15	3	1	16	12	4	0	6	1	0	4	41	16	1	16	6	0	600
Total			152	236	267	143	357	78	131	211	40	73	26	8	60	31	22	2	28	23	10	15	158	63	1	42	30	600	

Table 3　Time distances between shopping nodes (minutes)

Shopping nodes	Code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Intimex Supermarket	1	3	9	27	19	16	13	11	18	28	27	26	22	21	17	12	15	15	20	8	1	1	10	8	12	10
Trang Tien Plaza	2	9	5	35	18	25	22	5	27	37	36	35	31	30	26	21	19	14	14	17	8	6	3	1	5	2
Dong Xuan Market	3	27	35	5	20	10	16	37	21	1	2	7	10	5	16	18	14	18	23	22	27	17	36	35	38	36
Hang Be Market	4	19	18	20	3	5	10	19	21	21	20	20	15	14	19	11	6	4	4	15	19	4	18	18	17	19
Hang Dao-Ngang-Buom streets	5	16	25	10	5	7	4	28	14	12	10	10	6	5	9	8	4	8	12	12	17	7	26	24	27	26
Ham ca Map Building	6	13	22	16	10	4	3	22	15	17	16	16	12	11	14	6	3	2	7	9	13	3	22	21	24	22
Trang Tien bookshop	7	11	5	37	19	28	22	3	29	39	38	38	34	33	28	22	22	20	16	18	10	6	2	5	1	6
Hang Da Market	8	18	27	21	21	14	15	29	5	18	19	12	11	16	2	7	16	17	21	10	19	10	27	26	29	27
Hang Khoai street	9	28	37	1	21	12	17	39	18	3	3	6	11	7	15	19	16	19	24	23	28	18	37	36	39	37
Cau Dong Market	10	27	36	2	20	10	16	38	19	3	3	6	9	5	16	18	14	18	22	22	27	16	36	35	38	36
Hang Ma street	11	26	35	7	20	10	16	38	12	6	6	3	5	5	9	16	14	17	22	17	25	15	34	33	36	34
Lan Ong street	12	22	31	10	15	6	12	34	11	11	9	5	3	5	8	12	10	13	11	16	22	12	31	30	33	31
Hang Duong street	13	21	30	5	14	5	11	33	16	7	5	5	5	4	13	13	9	13	18	16	22	12	31	29	32	31
Hang Dieu street	14	17	26	16	19	9	14	28	2	15	16	9	8	13	2	9	14	16	21	9	17	10	26	25	28	25
Hang Gai street	15	12	21	18	11	8	6	22	7	19	18	16	12	13	9	3	8	8	15	4	12	4	21	20	23	21
Dinh Liet street	16	15	19	14	6	4	3	22	16	16	14	14	10	9	14	8	3	4	9	12	7	5	25	23	20	25
Cau Go street	17	15	14	18	4	8	2	20	17	19	18	17	13	13	16	8	4	3	5	11	15	3	19	20	19	21
Hang Dau street	18	20	14	23	4	12	7	16	21	24	22	22	11	18	21	15	9	5	3	16	20	1	14	15	14	16
Hang Trong street	19	8	17	22	15	12	9	18	10	23	22	17	16	16	9	4	12	11	16	4	8	2	17	16	19	17
Le Thai To street	20	1	8	27	19	17	13	10	19	28	27	25	22	22	17	12	7	15	20	8	4	1	9	8	11	9
Hoan Kiem Lake area	21	1	6	17	4	7	3	6	10	18	16	15	12	12	10	4	5	3	1	2	1	10	5	6	5	6
Trang Tien Shops	22	10	3	36	18	26	22	2	27	37	36	34	31	31	26	21	25	19	14	17	9	5	5	3	2	5
Hang Bai street	23	8	1	35	18	24	21	5	26	36	35	33	30	29	25	20	23	20	15	16	8	6	3	2	6	1
Dinh Le street	24	12	5	38	17	27	24	1	29	39	38	36	33	32	28	23	20	19	14	19	11	5	2	6	2	7
Hang Bai Supermarket	25	10	2	36	19	26	22	6	27	37	36	34	31	31	25	21	25	21	16	17	9	6	5	1	7	3

Table 4 Description of shopping nodes of Hanoi CCCD

No.	Shopping nodes	Description	Code	Shoping floor area (sq.m.)	Number of floor	Length of street (m)
1	Intimex Supermarket	Supermarket	1	3,000	2	
2	Trang Tien Plaza	Commercial building	2	20,000	7	
3	Dong Xuan Market	Indoor traditional market	3	14,000	3	
4	Hang Be Market area	Traditional market	4	3,395	1	
5	Ham ca Map Building area	Commercial building	6	4,900	5	
6	Trang Tien bookshop	Book shops	7	2,810	3	
7	***Hang Da Market***	***Commercial building***	***8***	***17,530 (3,716)***	***6(2)***	
8	Cau Dong Market	Traditional market	10	1,512	1	
9	Trang Tien Shops	Retail shops	22	3,659	1	
10	Hang Bai Supermarket	Electronic Supermarket	25	800	2	
11	Hang Dao-Ngang-Buom street	Shopping street	5	9,100		650
12	Hang Khoai street	Shopping street	9	3,010		320
13	Hang Ma street	Shopping street	11	3,220		320
14	Lan Ong street	Shopping street	12	2,660		250
15	Hang Duong street	Shopping street	13	3,696		370
16	Hang Dieu street	Shopping street	14	2,254		191
17	Hang Gai street	Shopping street	15	3,262		269
18	Dinh Liet street	Shopping street	16	2,041		170
19	Cau Go street	Shopping street	17	3,794		331
20	Hang Dau street	Shopping street	18	2,028		280
21	Hang Trong street	Shopping street	19	2,649		400
22	Le Thai To street	Shopping street	20	1,435		369
23	Hang Bai street	Shopping street	23	1,020		141
24	Dinh Le street	Shopping street	24	1,900		203
25	Hoan Kiem Lake area	Park and sightseeing place	21	20,000		

extent of efficiency a new store would perform. There are some approaches to estimate the potential of attracting consumers to a store at a given location such as the Huff gravity model, regression analysis, the analog model (Levy and Weitz, 2007) and so on. In Huff model (Huff, 1964), the probability that customer *i* shops at location *j* depends upon two factors : (i) the size of the store ; (ii) the

time distance to travel to the store. The larger the store, the greater the choice probability for shopping at that store, while the greater the travel time or distance to the store, the lower the choice probability for shopping at that store.

In this study, we have been motivated by the hierarchical disaggregate Huff model developed by Saito (1984a, 1984b), which incorporates the consumer's multistage choices among cities, among large retailers, and among shop-around destinations. His model is the origin of the Markov shop-around model with covariates. He considers that the essential point in modeling consumer shop-around behaviors is how to represent the consumers' multiple joint decisions about what to do at which place, so that the joint probability defined by the decision random variables concerned must be explained. His model becomes a multivariate fully recursive logit model with log-linear parameterization, called a multistage-decision disaggregate Huff model. This model for the first time describes consumers' hierarchical, i.e., sequential decisions concerning, in order, the choice of city to visit, the choice between large-scale shops and small-scale shops, and choice of second destination in his shopping trip chain. Here we follow the spirit of his model. The characteristic point of his method is that while the situation Huff originally considered is concerned with consumer's choice among shopping centers far away from each other in different cities, the situation where his model was applied is concerned with consumer's choice among shopping sites within a city or even within a CCCD. His method has been continuously developed by Saito and Ishibashi (1992) with incorporating covariates into the Markov chain model of consumer shop-around behaviors. They developed a model called a shop-around Markov model with covariates, which is used to estimate the change of consumer shop-around behaviors caused by the change of CCRE.

Based on the methodology developed by Saito and Ishibashi (1992a, b), we

construct an absorbing Markov chain model with covariates to forecast the consumer shop-around behaviors within the CCCD of Hanoi. As mentioned in Section 3, the CCRE of Hanoi includes 25 shopping nodes. Here we added a return home node 26 to these 25 shopping nodes. We model the consumer shop-around choice probability, P_{ij} from node i to node j as following equations :

$$P_{ij} = \frac{\frac{S_j^{\mu}}{T_{ij}^{\lambda'}}}{S_i^{\gamma} + \sum_{k \neq i} \frac{S_k^{\mu}}{T_{ik}^{\lambda'}}} \quad \text{for i and j = 1, ... ,25} \tag{4.1}$$

$$P_{ij} = \frac{S_i^{\gamma}}{S_i^{\gamma} + \sum_{k \neq i} \frac{S_k^{\mu}}{T_{ik}^{\lambda'}}} \quad \text{for j=26, i=1, ... ,25} \tag{4.2}$$

By using the usual multinomial logit model (MLM). The above shop-around Markov model can be estimated as follows.

$$log\ (P_{ij}) \propto (1-\delta_{ij})(\mu log S_j + \lambda log T_{ij}) + \delta_{ij}\gamma log\ S_i\ ,\ i=1... 25,\ j=1... 26 \tag{4.3}$$

where δ_{ij} denotes the Kronecker's delta, i.e., $\delta_{ij}=1$ if $j=26$ and $i=1$ to 25, and $\delta_{ij}=0$ otherwise, S_j denotes the shop floor space of the node j, T_{ij} is the time distance from node i to j, λ, $-\lambda'$, γ, μ are the parameters to be estimated. (here we put $\lambda=-\lambda'$)

Equation (4.1) expresses the shop-around choice probability P_{ij} where the destination j denotes another shopping node. The case of P_{ii} implies that consumers still do shopping at the same node i but changes their present purpose. With regard to equation (4.2), P_{ij} represent the probability to return home. It hypothesizes that the larger the shopping floor space of the present node, the higher the probability to quit shop-around.

5. Results of the forward forecasting analysis

5.1. Estimated results of the shop-around Markov model

In order to estimate the parameters in the formulation (4.3), the data in Table 1, Table 2, Table 3 and Table 4 are used as input data for estimating conditional logit model by the MDC procedure in Statistical Analysis Software (SAS).

Table 5 shows the estimated results for the case using the on-site survey data in

Table 5-1 Shop-around model estimated by using the survey data in 2004

The SAS System 11:13 Monday, September 26, 2011 5

The MDC Procedure

Conditional Logit Estimates

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	6146.7	2 * (LogL - LogL0)
Upper Bound of R (U)	18715	- 2 * LogL0
Aldrich-Nelson	0.6816	R / (R+N)
Cragg-Uhler 1	0.8824	1 - exp(-R/N)
Cragg-Uhler 2	0.8837	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.9253	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.9251	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.3284	R / U
Veall-Zimmermann	0.7861	(R * (U+N)) / (U * (R+N))

N = # of observations, K = # of regressors

Table 5-2 Shop-around model estimated by using the survey data in 2004

Conditional Logit Estimates

Parameter Estimates

Parameter	DF	Coefficients	Estimate	Standard Error	t Value	Approx Pr > |t|
LOGSJ	1	μ	0.4895	0.0206	23.80	<.0001
LOGTIJ	1	λ	-1.3034	0.0251	-52.00	<.0001
LOGSI	1	γ	0.4588	0.0205	22.43	<.0001

2004, which is the case of forward forecasting from 2004 to forecast the shop-around visits of 2011 after the new Hang Da Market re-opened.

The estimated results in Table 5 show that all variables are strongly significant and the signs of the coefficients are the same as the hypothesis postulated.

5.2. Forecasted results of consumer shop-around movements

Here we carry out to forecast consumer shop-around movements within the CCCD of Hanoi at two points of time corresponding to before and after the redevelopment of Hang Da Market following the process of calculation stated in Subsection 3.1 and formulation of Markov chain model.

After estimating the coefficients of the shop-around Markov model, we use this model to predict the shop-around choice probabilities among shopping nodes (P_{II}) based on the change of shopping floor space of Hang Da Market. As for the probability distribution of entry visits to shopping nodes (P_{HI}), we employ the estimated results of observed probability distributions of entry visits obtained from OD density by using the consistent estimation method as the estimates of P_{HI} for 2004 and 2011, i.e., before and after the redevelopment of Hang Da Market.

As for total entry visits to the CCCD, we use the estimated results in 2004 with value of 95,440 visits per day and 100,473 visits per day in 2011 (Cf. [19], [20]). The forecasted numbers of shop-around movements, before and after the redevelopment of Hang Da Market are shown in Table 6.

6. Results of the backward forecasting analysis

6.1. Estimated results of the shop-around Markov model

Data used for calculating the backward forecast is the on-site survey data in

Table 6 Summary of the forecasted numbers of consumers' shop-around visits (Forward forecast by using the survey data in 2004)

Code	Shopping Nodes	Before redeveloping Hang Da market *(Forecasted results in 2004)*				After redeveloping Hang Da market *(Forecasted results in 2011)*			
		Entry visit	Shop-around visit (B)		Total	Entry visit	Shop-around visit (B)		Total
		(A)	Around visit (b1)	Sojourn visit (b2)	C=A+B	(A)	Around visit (b1)	Sojourn visit (b2)	C=A+B
1	Intimex Supermarket	10,385	11,606	1,097	23,088	9,186	12,708	1,086	22,980
2	Trang Tien Plaza	4,710	15,428	1,651	21,790	4,504	16,255	1,695	22,454
3	Dong Xuan Market	4,501	12,424	1,236	18,161	5,371	12,136	1,270	18,777
4	Hang Be Market	9,014	5,972	1,610	16,596	6,907	5,605	1,330	13,842
5	Hang Dao- Ngang-Buom street	27,437	8,544	1,726	37,706	23,440	8,249	1,499	33,188
6	Ham ca map Buiding	2,473	10,764	1,252	14,489	5,090	9,701	1,383	16,174
7	Trang tien book shop	10,622	6,887	1,343	18,851	6,099	7,973	1,074	15,146
8	***Hang Da Market***	***2,136***	***3,519***	***394***	***6,049***	***9,831***	***7,527***	***1,774***	***19,132***
9	Hang Khoai Street	1,094	7,514	556	9,165	2,217	7,413	617	10,247
10	Cau Dong Market	2,382	3,613	427	6,422	1,553	3,536	358	5,448
11	Hang Ma street	71	3,650	487	4,209	91	3,486	456	4,033
12	Lan Ong Street	65	3,374	361	3,800	78	3,185	332	3,595
13	Hang Duong street	3,952	5,279	748	9,980	1,117	5,066	494	6,677
14	Hang Dieu street	91	3,591	649	4,331	783	4,567	751	6,102
15	Hang Gai street	563	5,251	622	6,436	351	5,376	588	6,315
16	Dinh Liet street	447	5,211	400	6,058	1,369	4,870	435	6,675
17	CauGo Street	6,883	8,315	1,333	16,531	1,048	8,457	825	10,331
18	Hang Dau Street	1,304	8,894	481	10,679	19	9,251	435	9,706
19	Hang Trong street	591	5,682	355	6,629	206	5,984	343	6,532
20	Le Thai To street	1,290	9,867	258	11,416	2,397	10,393	295	13,085
21	Hoan Kiem Lake area	1,356	45,638	858	47,852	8,499	44,558	960	54,017
22	Trang Tien shops	650	8,357	399	9,405	3,527	8,282	520	12,329
23	Hang Bai street	418	6,423	353	7,195	301	6,774	364	7,439
24	Dinh Le street	1,421	7,993	984	10,398	4,137	7,424	1,202	12,763
25	Hang Bai Supermarket	1,584	3,533	218	5,335	2,351	3,633	254	6,238
	Total	**95,440**	**217,329**	**19,801**	**332,570**	**100,473**	**222,411**	**20,339**	**343,223**

2011 after Hang Da Market has re-opened. Table 7 shows the estimated results of the shop-around Markov model.

Similarly to the forward forecasting analysis, Table 7 shows that all variables are strongly significant and the signs of the coefficients are the same as the hypothesis postulated.

Table 7-1 Shop-around model estimated by using the survey data in 2011

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                                    The MDC Procedure
                                Conditional Logit Estimates
                                 Goodness-of-Fit Measures

          Measure                          Value    Formula

          Likelihood Ratio (R)           3970.6    2 * (LogL - LogL0)
          Upper Bound of R (U)            14381    - 2 * LogL0
          Aldrich-Nelson                 0.6427    R / (R+N)
          Cragg-Uhler 1                  0.8345    1 - exp(-R/N)
          Cragg-Uhler 2                  0.8358    (1-exp(-R/N)) / (1-exp(-U/N))
          Estrella                       0.8782    1 - (1-R/U)^(U/N)
          Adjusted Estrella              0.8777    1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
          McFadden's LRI                 0.2761    R / U
          Veall-Zimmermann               0.7414    (R * (U+N)) / (U * (R+N))
          N = # of observations, K = # of regressors
```

Table 7-2 Shop-around model estimated by using the survey data in 2011

```
The SAS System   13:52 Friday, August 5, 2011  82
                                The MDC Procedure
                            Conditional Logit Estimates
                                 Parameter Estimates

                                                      Standard                 Approx
    Parameter      DF    Coefficient     Estimate      Error      t Value      Pr > |t|

    LOGS_j          1         μ            0.6871       0.0236      29.10      <.0001
    LOGT_ij         1         λ           -1.1102       0.0268     -41.45      <.0001
    LOGS_i          1         γ            0.6326       0.0228      27.69      <.0001
```

6.2. Forecasted results of consumer shop-around movements

Table 8 shows the forecasted numbers of visits to shopping nodes at two points of time, before and after the redevelopment of Hang Da Market.

7. Assessing the accuracy of the forecasting model

In this section, we evaluate the accuracy of the forecasted results obtained from

Table 8 Summary of the forecasted numbers of consumers' shop-around visits (Backward forecast by using the survey data in 2011)

Code	Shopping Nodes	Before redeveloping Hang Da market *(Forecasted results in 2004)*				After redeveloping Hang Da market *(Forecasted results in 2011)*			
		Entry visit	Shop-around visit (B)		Total	Entry visit	Shop-around visit (B')		Total
		(A)	Around visit (b1)	Sojourn visit (b2)	C=A+B	(A')	Around visit (b'1)	Sojourn visit (b'2)	C'=A'+B'
1	Intimex Supermarket	10,385	14,478	1,162	26,025	9,186	14,607	1,097	24,890
2	Trang Tien Plaza	4,710	26,849	4,200	35,760	4,504	26,684	4,100	35,288
3	Dong Xuan Market	4,501	20,828	2,884	28,213	5,371	19,509	2,784	27,663
4	Hang Be Market	9,014	8,681	1,722	19,417	6,907	8,005	1,419	16,331
5	Hang Dao- Ngang-Buom street	27,437	15,330	2,786	45,553	23,440	14,441	2,394	40,274
6	Ham ca map Buiding	2,473	15,448	1,697	19,618	5,090	13,883	1,753	20,726
7	Trang tien book shop	10,622	8,084	1,409	20,115	6,099	8,669	1,097	15,866
8	***Hang Da Market***	***2,136***	***5,726***	***608***	***8,470***	***9,831***	***15,410***	***3,797***	***29,038***
9	Hang Khoai Street	1,094	10,143	686	11,923	2,217	9,576	707	12,501
10	Cau Dong Market	2,382	4,673	391	7,445	1,553	4,408	322	6,283
11	Hang Ma street	71	5,694	707	6,473	91	5,362	634	6,087
12	Lan Ong Street	65	4,608	399	5,072	78	4,303	353	4,733
13	Hang Duong street	3,952	8,048	970	12,970	1,117	7,556	678	9,351
14	Hang Dieu street	91	5,088	741	5,920	783	6,121	714	7,619
15	Hang Gai street	563	8,004	821	9,388	351	7,909	735	8,994
16	Dinh Liet street	447	6,191	357	6,995	1,369	5,687	369	7,425
17	CauGo Street	6,883	11,880	1,550	20,313	1,048	11,531	1,016	13,595
18	Hang Dau Street	1,304	10,900	471	12,675	19	10,617	406	11,042
19	Hang Trong street	591	8,231	444	9,267	206	8,168	404	8,778
20	Le Thai To street	1,290	10,197	226	11,713	2,397	10,067	242	12,706
21	Hoan Kiem Lake area	1,356	69,348	2,494	73,198	8,499	65,042	2,540	76,081
22	Trang Tien shops	650	10,998	548	12,196	3,527	10,509	651	14,687
23	Hang Bai street	418	6,485	245	7,149	301	6,446	237	6,985
24	Dinh Le street	1,421	8,195	829	10,445	4,137	7,484	988	12,610
25	Hang Bai Supermarket	1,584	3,625	155	5,364	2,351	3,540	172	6,064
Total		**95,440**	**307,732**	**28,504**	**431,676**	**100,473**	**305,533**	**29,610**	**435,616**

the shop-around Markov chain model with covariates. By doing this, we would like to assess the applicability and efficacy of the method by considering the conditions of retail environments and consumer shop-around behaviours of Hanoi.

For this purpose, we evaluate the accuracy of our forecasting model in two ways. The first is the evaluation in terms of shop-around choice probabilities. The second is the evaluation in terms of numbers of visitors to shopping nodes.

7.1. Evaluating the accuracy of forecasted shop-around choice probability

Here we have two estimated shop-around Markov structure models for 2004 and 2011 by using respective observed shop-around probabilities obtained by the consistent estimation method using two on-site survey data in 2004 and 2011. Thus we evaluate 2004 model by measuring the accuracy to compare the forecasted shop-around probabilities with the observed shop-around probabilities in 2011. This is the forward forecasting analysis. In the same way, we can carry out the backward forecasting analysis.

The measurement of the accuracy of forecast can be placed into one of two classes. One is "scale-dependent" and the other not (Hyndman and Koehler 2006). Scale-dependent measures should be used with care when making the accuracy comparisons across data sets since the different scales affect the magnitude of these measures so that it is likely to be miss-interpreted as differences in accuracy. The most commonly used scale-dependent summary measures of forecasting accuracy are based on the distribution of absolute errors or squared errors. One of measures that are not scale–dependent is the percentage error.

In this study, we calculate the values of Mean Square Error (MSE) and Mean Absolute Percentage Error (MAPE) to measure the forecasting accuracy of the method. These measures are formulated as equations below :

• *Mean Square Error (MSE)*

$$MSE = \chi^2 = \frac{1}{n(n+1)} \sum_{i=1}^{n} \sum_{j=1}^{n+1} \left(P_{ij}^{pred} - P_{ij}^{Obs} \right)^2 \tag{5.6}$$

• *Mean Absolute Percentage Error (MAPE)*

$$MAPE = \frac{1}{n(n+1)} \sum_{i=1}^{n} \sum_{j=1}^{n+1} \left| \frac{P_{ij}^{pred} - P_{ij}^{Obs}}{P_{ij}^{pred}} \right| * 100 \qquad (5.7)$$

where P_{ij}^{pred} is the prediction of choice probability obtained by using the shop-around structure model, P_{ij}^{Obs} is observed choice probability obtained by the consistent estimation method using the on-site survey data; n is number of shopping nodes (n=25). Total of observation number is $N = n(n+1)$.

Here, we calculate the values of MSE and MAPE for two cases. In case 1, we assess the accuracy for the whole observations with a total of 650 observations. For case 2, we restrict our attention only on the shop-around probabilities related to Hang Da Market. That is to say, the calculation is restricted to the row and the column for the Hang Da Market. The results are shown in Table 9.

Table 9 Results of measuring the forecast accuracy of shop-around model

Mesures	The forward forecasting analysis		The backward forecasting analysis	
	MSE	MAPE(%)	MSE	MAPE(%)
Case1	0.0055	110.69	0.0121	137.58
Case2	0.0018	78.44	0.0045	136.29

The results in Table 9 show that the level of the accuracy of shop-around Markov model for Hang Da Market becomes smaller than case 1 for all shopping nodes in the CCCD of Hanoi, especially for the forward forecasting analysis. The forecasting error in both cases is large in this empirical study.

7.2. Comparing the forecasted number of visitors with the estimates of consistent estimation method

Besides measuring the forecasting accuracy of shop-around choice probabilities predicteded by the shop-around structure model, we would like to compare the forecasted numbers of visitors to shopping sites obtained by the shop-around Markov chain model with the estimated numbers of visitors obtained by the consistent OD estimation method. If the difference of results of two methods is not too much, this would reflect partly the accuracy of these empirical studies.

In Table 10, we summarize the forecasted numbers of visitors to shopping sites after Hang Da Market redevelopment by the shop-around Markov chain model with covariates following the forward forecasting analysis and the actual numbers of visitors to shopping nodes estimated by the consistent OD estimation method at the same point of time.

From Table 10, we see that the total of forecasted numbers of visitors to shopping nodes in the CCCD Hanoi is almost the same as the one from the consistent estimation method. Especially the forecasted result of visitors to Hang Da Market after the redevelopment is quite accurate.

However, there is still much difference if we compare specifically the numbers of visitors to each shopping node or each kind of shop-around visits (shop-around visits and sojourn visits).

Similarly, we can compare the forecasted results in 2004 calculated from the backward forecasting analysis with the estimated results in 2004 by using the consistent estimation method. The reslt is shown in Table 11.

Compared with the forward forecasting analysis, this backward forecasting analysis has larger error. However, overall we think that the differences in errors of this empirical study are acceptable.

Table 10 Comparison of estimated results between two methods (After the redevelopment of Hang Da Market in 2011)

Code	Shopping Nodes	Estimated results *(Using consistent OD estimation method)*				Forecasted results *(Using the Markov chain model with covariates)*			
		Entry visit	Around visit	Sojourn visits	Total	Entry visit	Around visit	Sojourn visits	Total
		(A')	(b'1)	(b'2)	C'=A'+B'	(A")	(b"1)	(b"2)	C"=A"+B"
1	Intimex Supermarket	*9,186*	*10,089*	*18,022*	37,297	*9,186*	*12,708*	*1,086*	22,980
2	Trang Tien Plaza	*4,504*	*3,075*	*8,520*	16,099	*4,504*	*16,255*	*1,695*	22,454
3	Dong Xuan Market	*5,371*	*7,569*	*15,376*	28,316	*5,371*	*12,136*	*1,270*	18,777
4	Hang Be Market	*6,907*	*9,652*	*13,122*	29,681	*6,907*	*5,605*	*1,330*	13,842
5	Hang Dao- Ngang-Buom street	*23,440*	*13,137*	*27,066*	63,643	*23,440*	*8,249*	*1,499*	33,188
6	Ham ca map Buiding	*5,090*	*8,884*	*1,203*	15,176	*5,090*	*9,701*	*1,383*	16,174
7	Trang tien book shop	*6,099*	*13,315*	*5,667*	25,081	*6,099*	*7,973*	*1,074*	15,146
8	***Hang Da Market***	***9,831***	***6,785***	***7,188***	**23,804**	***9,831***	***7,527***	***1,774***	**19,132**
9	Hang Khoai Street	*2,217*	*4,321*	*83*	6,622	*2,217*	*7,413*	*617*	10,247
10	Cau Dong Market	*1,553*	*6,014*	*503*	8,070	*1,553*	*3,536*	*358*	5,448
11	Hang Ma street	*91*	*3,345*	*0*	3,436	*91*	*3,486*	*456*	4,033
12	Lan Ong Street	*78*	*380*	*34*	492	*78*	*3,185*	*332*	3,595
13	Hang Duong street	*1,117*	*3,597*	*416*	5,130	*1,117*	*5,066*	*494*	6,677
14	Hang Dieu street	*783*	*2,401*	*0*	3,184	*783*	*4,567*	*751*	6,102
15	Hang Gai street	*351*	*3,409*	*915*	4,675	*351*	*5,376*	*588*	6,315
16	Dinh Liet street	*1,369*	*66*	*0*	1,436	*1,369*	*4,870*	*435*	6,675
17	CauGo Street	*1,048*	*3,307*	*198*	4,554	*1,048*	*8,457*	*825*	10,331
18	Hang Dau Street	*19*	*2,852*	*0*	2,871	*19*	*9,251*	*435*	9,706
19	Hang Trong street	*206*	*1,369*	*0*	1,575	*206*	*5,984*	*343*	6,532
20	Le Thai To street	*2,397*	*4,554*	*0*	6,951	*2,397*	*10,393*	*295*	13,085
21	Hoan Kiem Lake area	*8,499*	*23,473*	*4,100*	36,073	*8,499*	*44,558*	*960*	54,017
22	Trang Tien shops	*3,527*	*8,448*	*3,151*	15,126	*3,527*	*8,282*	*520*	12,329
23	Hang Bai street	*301*	*0*	*0*	301	*301*	*6,774*	*364*	7,439
24	Dinh Le street	*4,137*	*1,545*	*5,687*	11,369	*4,137*	*7,424*	*1,202*	12,763
25	Hang Bai Supermarket	*2,351*	*1,919*	*2,140*	6,411	*2,351*	*3,633*	*254*	6,238
Total		**100,473**	**143,506**	**113,392**	**357,371**	**100,473**	**222,411**	**20,339**	**343,223**
Ratios to entry visit		**1.00**	**1.43**	**1.13**	**3.56**	**1.00**	**2.21**	**0.20**	**3.42**

8. Conclusion

In this paper, we try to apply Markov chain model combined with the covariates to forecast the changes of consumer shop-around movements after Hang Da Market redevelopment based on the on-site survey data conducted in 2004 and 2011. This study is viewed as the first research in this field in Vietnam.

Table 11 Comparison of estimated results between two methods (Before the redevelopment of Hang Da Market in 2004)

Code	Shopping Nodes	Estimated results *(Using consistent OD estimation method)*				Forecasted results *(Using the Markov chain model with covariates)*			
		Entry visit	Around visit	Sojourn visits	Total	Entry visit	Around visit	Sojourn visits	Total
		(A')	(b'1)	(b'2)	C'=A'+B'	(A")	(b"1)	(b"2)	C"=A"+B"
1	Intimex Supermarket	*10,385*	*2,359*	*14,541*	27,284	*10,385*	*14,478*	*1,162*	26,025
2	Trang Tien Plaza	*4,710*	*2,127*	*6,186*	13,023	*4,710*	*26,849*	*4,200*	35,760
3	Dong Xuan Market	*4,501*	*8,439*	*12,855*	25,795	*4,501*	*20,828*	*2,884*	28,213
4	Hang Be Market	*9,014*	*8,850*	*24,486*	42,350	*9,014*	*8,681*	*1,722*	19,417
5	Hang Dao- Ngang-Buom street	*27,437*	*1,799*	*56,492*	85,728	*27,437*	*15,330*	*2,786*	45,553
6	Ham ca map Buiding	*2,473*	*3,482*	*3,342*	9,297	*2,473*	*15,448*	*1,697*	19,618
7	Trang tien book shop	*10,622*	*6,286*	*12,264*	29,172	*10,622*	*8,084*	*1,409*	20,115
8	***Hang Da Market***	***2,136***	***230***	***0***	**2,367**	***2,136***	***5,726***	***608***	**8,470**
9	Hang Khoai Street	*1,094*	*2,640*	*0*	3,734	*1,094*	*10,143*	*686*	11,923
10	Cau Dong Market	*2,382*	*5,263*	*1,603*	9,247	*2,382*	*4,673*	*391*	7,445
11	Hang Ma street	*71*	*0*	*0*	71	*71*	*5,694*	*707*	6,473
12	Lan Ong Street	*65*	*27*	*0*	92	*65*	*4,608*	*399*	5,072
13	Hang Duong street	*3,952*	*35*	*633*	4,620	*3,952*	*8,048*	*970*	12,970
14	Hang Dieu street	*91*	*0*	*0*	91	*91*	*5,088*	*741*	5,920
15	Hang Gai street	*563*	*90*	*0*	653	*563*	*8,004*	*821*	9,388
16	Dinh Liet street	*447*	*436*	*0*	882	*447*	*6,191*	*357*	6,995
17	CauGo Street	*6,883*	*6,709*	*3,401*	16,993	*6,883*	*11,880*	*1,550*	20,313
18	Hang Dau Street	*1,304*	*2,450*	*0*	3,753	*1,304*	*10,900*	*471*	12,675
19	Hang Trong street	*591*	*0*	*0*	591	*591*	*8,231*	*444*	9,267
20	Le Thai To street	*1,290*	*141*	*234*	1,665	*1,290*	*10,197*	*226*	11,713
21	Hoan Kiem Lake area	*1,356*	*7,714*	*72*	9,141	*1,356*	*69,348*	*2,494*	73,198
22	Trang Tien shops	*650*	*6,152*	*817*	7,619	*650*	*10,998*	*548*	12,196
23	Hang Bai street	*418*	*522*	*0*	941	*418*	*6,485*	*245*	7,149
24	Dinh Le street	*1,421*	*4,427*	*385*	6,232	*1,421*	*8,195*	*829*	10,445
25	Hang Bai Supermarket	*1,584*	*1,351*	*0*	2,935	*1,584*	*3,625*	*155*	5,364
Total		**95,440**	**71,527**	**137,310**	**304,277**	**95,440**	**307,732**	**28,504**	**431,676**
Ratios to entry visit		**1.00**	**0.75**	**1.44**	**3.19**	**1.00**	**3.22**	**0.30**	**4.52**

The estimated results of parameters in the shop-around Markov model are strongly significant and the signs of their coefficients are the same as the hypothesis postulated. This demonstrates that the shop-around Markov model formulated based on two variables of time distance and shopping floor area is appropriate for explaining Hanoi consumer shop-around behaviors in the CCCD of Hanoi.

By comparing the forecasted results of this method with the estimated numbers of visitors obtained by the consistent OD estimation method, we realized that the

forecasted results show the significant accuracy enough to prove its applicability and efficacy for planning works and making feasible projects.

In this study, we only formulate the shop-around structure model to estimate the change of shop-around effects. As for the entry structure model, it has not yet been constructed. This might be seen as a deficiency of the study. This issue would be a topic of our further research.

Up to now, there have been no previous studies that are approached from the viewpoint of consumer shop-around behaviors in Vietnam. Our study is the first one that employs the concept of consumer shop-around behaviors and applies the shop-around Markov model with covariates to forecast changes of consumers shop-around movements when the retail environment is changed in the CCCD of Hanoi.

Considering the crucial problem PCH now faces for planning the modernization of CCCD of Hanoi, we believe that our approach with emphasis on consumer shop-around behaviors has critical importance for solving the problem. This is because redevelopment projects for traditional markets should be sustainable in the sense that redeveloped traditional markets should subsist and possibly make a continuous growth with the behavioral supports by Hanoi's consumers.

Thus we should investigate more fully the consumer behaviors before launching redevelopment projects for inducing gradual changes of consumer behaviors while keeping a precious historical asset of CCCD of Hanoi as a system of many traditoinal markets.

We hope this research evokes many furher researches to shape and develop the approach based on the consumer shop-aorund behaviors in Vietnam.

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