

## **TRIP CHAINING PATTERNS IN BANGKOK: BASED ON HOUSEHOLD TRAVEL SURVEY**

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### **ABSTRACT**

This paper analyzed trip chaining in Bangkok from a home interview survey, compiled and organized as a part of Urban Transport Database and Model development project. The travel data were rearranged into trip chains. Trip chaining patterns were investigated. Analyses revealed various trip chaining characteristics. Trip chaining in Bangkok is noticeably different from other cities in Europe and North America. Trip chains are in detail examined in relation to various attributes, including trip type, purpose of travel, mode use, gender, temporal as well as spatial variables. The paper examines how travelers in Bangkok chain their destinations and the relationship between trip chaining and traveler and trip attributes.

### **1. INTRODUCTION**

Bangkok is one of the busiest metropolises where traffic congestion has been a chronic problem over many hours in a day. Due to the limitation in mobility and with rush environments, people are likely to optimize their travel by adapting their travel decisions. Many social changes, such as demography, workforce, and lifestyles, also induce the change in travel behaviors. As a result, a larger percentage of daily trips is made with multiple stops before destining home or the linkage of the destinations is formed. The same phenomenon and trend are found everywhere in the world. The realization of this travel behavior is important in that transportation planners would well understand the nature of population's complex travel decisions and bring about a more accurate modeling of travel demand, based on realistic travel characteristics.

Trip chaining is an issue that is increasingly interested by many researchers in travel behaviors and demand modeling. Trip chaining is a determinant of travel choices that are derived from individual characteristics. Also all trips in one day may have influence on each other and are constrained by time and space available for movements. Since traditional demand models postulate a bare assumption on a single loop of travel formation, the models are not capable of reflecting various policy changes and recent changes travel habits, including changing non-work activities and trip chaining. Much evidence shows that the number of trip chaining increases and impacts several outcomes such as vehicle-miles of travel and number of trips (O'Kelly and Miller, 1984). The trip chaining is realized in practice and some adjustments are made to take into account of this trip type (Siaurusaitis and Saben, 1997).

## 2. DEFINITION OF TRIP CHAINING

Trip chaining is defined as a connected sequence of trips to visit more than one destination (Jang, 1996). Each travel between one origin-destination can be called a chain leg or link and its termination is called a stop or sojourn. Trip chaining, by definition, contains more than one link or stop in the entire journey. Many of past research defined a home-to-home circuit as a tour and trip chains as a complete home-to-home circuit over 24 hour period; for instance, work by Wegmann and Jang (1998). This implies that a trip chaining may have more than one tour. A simple chain is defined as a round trip from/to one destination (in particular from/to home), otherwise a complex chain. The terminology of the trip chains is shown in Figure 1.

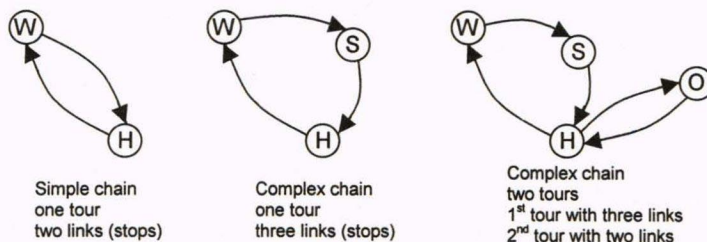


Figure 1. Definition of Trip Chains

## 3. SOURCE OF DATA

The study utilized data from a large home interview survey, which was carried out in Greater Bangkok Area during 1995 and 1996 as part of the Urban Transport Database and Model (UTDM) development project. A total travel survey of 7879 households was completed, accounting for 0.28% of the total number of households in the area. The raw data contained a total of 18105 daily individual chains or 38951 unlinked trips.

The original data from the survey were stored in three files: Household data file, Personal data file, and Trip Making data file. Although another data file linking the three files are available, this "linked trip file" is constructed for transport modeling purpose and loses several information on trip linkages. Therefore, a new database linking three data files is developed, with focus on traveler's individual links/tours. This file was then used to construct trip chains. A number of 2498 unlinked trips or 6.4% of the total travels, however, were ignored as they did not have trip continuity and were classified as errors in coding.

In construction of trip chaining patterns, attention must be paid on the determination of a link. The survey data provide disaggregate "parts" of journey which are then connected to a link in a travel chain. A link of trip is formed by one or more "part"



leading to the single purpose at a destination, no matter there might be a mode change during the travel. Figure 2 shows an example of the formation of links.

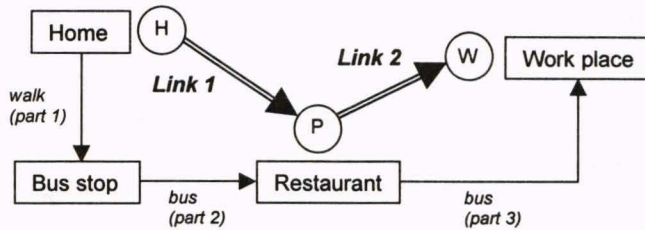


Figure 2. Formation of a link

Finally, a trip chain is formed as a series of travel connecting activities in an entire day by an individual.

#### 4. TRIP CHAINING PATTERNS

Patterns of trip chaining are studied by exploring sequences of travel linking activities in the entire database. Various patterns of trip chaining are disclosed. These trip patterns are defined and/or named in certain ways. The chain patterns can be titled by sequences of activity purposes at stops. The home interview data provide 10 categories of trip purposes. The database contain 309 different sequences of trip chains from the total 17602 chains. Since the patterns of trips are dispersed, trip chaining patterns are further grouped for better examination and for use in comparison with other studies.

Trip chains can be classified into work and non-work related chains. The work chains involve obligatory work trips, while non-work chains link activities which are considered discretionary. The work chains make up a primary share in the total population travel. Many studies focus their investigation on this type of movement. School trips are also of importance as work trips. Although they are grouped as a non-work travel, the school trips are treated with special consideration.

Alternatively, the trip patterns can be grouped by number of stops or tours in the chains. The investigation displays number of activities completed by individuals. Number of tours and stops imply the complexity of the trips.

Trip chaining patterns can also be divided into simple and complex chains. This classification separates trips made by complicated decision from conventional and straight-forward round trips. This classification is easy to understand and therefore used throughout this study.

## 5. FINDINGS

### 5.1 Basic Data on Trip Chaining Patterns

A basic result of trip chaining patterns in Bangkok is shown in Table 1.

**Table 1. Basic data for trip chaining in Bangkok**

a) Number of trip chains by number of links (stops)

No. of links	1	2	3	4	5	6	7	8	>8
No. of chains	-- (191)	16161 (16234)	622 (628)	686 (688)	86 (86)	83 (83)	21 (21)	17 (17)	4 (4)
Percent	--	91.41	3.52	3.88	0.49	0.47	0.11	0.10	0.02

Note: from raw data, excluding (daily) non-home based trips, N = 17680  
( ) is drawn from the raw data, N = 17952

b) Number of trip chains by number of tours

No. of tours	1	2	3	>3
No. of chains	17386	333	37	8
Percent	97.87	1.87	0.21	0.05

Note: from home-based chains, N = 17764

c) Number of simple and complex chains by work-related type

Area	Type of Chains	Number of samples			Percent
		Work	Non-work	Number of trip makers	
Bangkok and vicinity	Simple	10075	6071	29778	91.40
	Complex	1135	384		8.60
Bangkok	Simple	5162	3417	14252	90.84
	Complex	647	222		9.16
Vicinity	Simple	4913	2654	15526	92.09
	Complex	488	162		7.91

Note: from raw data, N = 17765

The majority of trips is made of two-link movements or the simple tours. The one-link travel in the raw data means that the origin and the final destination is not identical. The raw data contain a number of chains that either did not start or end at home. These particular trip chains are ignored in the further consideration. The raw data show that 98% of trips are made with one tour.

The travel chains are classified as work vs. non-work travel and as simple vs. complex chains. Table 1c depicts a number of raw samples in each category. However, detailed analysis indicates that each geographical area has different sampling rate. In Bangkok the sample size is 0.19% of total area population and in vicinity the size ranges from 0.13% to 0.62% in five provinces. Thus, it is reasonable to adjust the percent of trip chains in each group for the different sampling rate in the vicinity area and the adjusted values are then compared with Bangkok figures. The results of the



adjusted values and percent of trip chaining in each category are presented in the subsequent section (Table 2).

## 5.2 Comparison of Trip Chaining by Geographical Areas

**Table 2. Trip chaining classified by residential locations**

Area	Trip type	Estimated total number of trips		
		Work	Non-work	Total
Bangkok and vicinity	Simple chain	4156209	2634852	6791121
	%	56.25	35.66	91.91
	Complex chain	445439	152305	597744
	%	6.03	2.06	8.09
Bangkok	Simple chain	2716842	1798421	4515263
	%	54.64	36.17	90.80
	Complex chain	340526	116842	457368
	%	6.85	2.35	9.20
Vicinity	Simple chain	1439437	836431	2275858
	%	59.57	34.62	94.19
	Complex chain	104913	35463	140376
	%	4.34	1.47	5.81

Table 2 illustrates simple and complex chains performed by travelers residing in different areas. The table was constructed by multiplying the sample data with population in each area, to yield an estimated total number of trips in each area. Considering Bangkok and vicinity combined, an average of 8.1% of the total trips in one day is chained. In Bangkok, the percentage of chained trips is 9.2%, higher than 5.8% in vicinity. Among five provinces in the vicinity, the percentage of chained trips varies from 2.8% to 16.2%. Note that the average trip frequency is 1.47 trips per person and 1.10 trips per person in one-day travel in Bangkok and vicinity, respectively. It means that people who live in the city center tend to travel to more destinations and combine their trip legs into chains more than the persons who live outside.

Work trips are more likely to be chained than the non-work trips. On average Bangkok and vicinity combined, 9.7% of work trips are complex, while the percent of complex trips for non-work travel is 5.5%. In other words, approximately 75% of complex trips are work trips. The trip chaining characteristics by trip purposes in Bangkok and in vicinity are significantly different. In Bangkok, 11.1% of work trips and 6.1% of non-work trips are complex trips, compared to 6.8% of work trips and 4.1% of non-work trips in vicinity. The differences are statistically significant at 99%. It is remarked that the proportions of the work trips in total complex chains are very similar in both areas.

Possible explanation are transportation system availability, travel time, and mode usage. The provision of transportation system in Bangkok area is somewhat in a greater extent than the outer areas, although average travel time is longer due to congestion. This makes it easy to find transportation/choices of destination for the

next links. The average travel time in Bangkok is slightly higher than that in vicinity. (56.6 vs. 54.7 minutes per person). The other reason is that people in Bangkok area use public transport more than people in the vicinity. The situation of long-time travel and mode transfer make it easy to have more activities and join several activities into a single tour.

### 5.3 Comparison of Trip Chaining in Bangkok and Other Countries

Trip chaining in Greater Bangkok is compared with data from Portland and the Netherlands (Strathman, Dueker, and Davis, 1994) and presented in Table 3. The data were drawn from the raw data which were assumed truly random sampling and no adjustment for any bias was made. The category "Anything else" includes the trips which their origins is not from home and the trips which their purposes cannot be classified in any categories listed in the Table. Since the home survey and most studies focus on work trips, it is plausible, but still questionable, to include these trips as non-work trips.

Table 3. Comparison of trip chaining in different countries

Purpose	No.	Chain Type	Portland*		The Netherlands*		Greater Bangkok	
			No.	%	No.	%	No.	%
<b>1. Simple Chains</b>								
work	1.1	Home-work-home	2000	25.1	5277	15.3	10085	57.3
non-work	1.2	Home-school-home	1289	16.2	2834	8.2	5327	30.3
	1.3	Home-shop-home	761	9.6	5211	15.1	538	3.1
	1.4	Home-social/recreational-home	737	9.3	8971	26.0	6	0.0
	1.5	Home-personal business-home	733	9.2	1205	3.5	82	0.5
	1.6	Home-serve passenger-home	353	4.4	1935	5.6	62	0.4
	1.7	Home-other-home	190	2.4	1615	4.7	56	0.3
Total simple chains			6063	76.1	27048	78.4	16156	91.8
<b>2. Complex Chains</b>								
work	2.1	Home-work-work-home	125	1.6	616	1.8	19	0.1
	2.2	Home-work-shop-home	88	1.1	241	0.7	36	0.2
	2.3	Home-work-other than shop, work, home-home	298	3.7	585	1.7	78	0.4
	2.4	Home-other than work-work-home	172	2.2	0.0	0.0	98	0.6
non-work	2.5	Home-school-other than home-home	135	1.7	514	1.5	57	0.3
	2.6	Home-personal business/serve passenger-shop-home	122	1.5	333	1.0	12	0.1
	2.7	Home-personal business/serve passenger-social/recreational-home	55	0.7	351	1.0	0.0	0.0
	2.8	Home-personal business/serve passenger-other than shop or social/recreational-home	296	3.7	432	1.3	288	1.6
	2.9	Home-shop-shop-home	129	1.6	474	1.4	1.0	0.0
	2.10	Home-shop-social/recreational-home	29	0.4	330	1.0	0.0	0.0
	2.11	Home-shop-social/recreational-social/recreational-home	67	0.8	1100	3.2	0.0	0.0
	2.12	Home-social/recreational-shop-home	33	0.4	351	1.0	0.0	0.0
	2.13	Home-other-other-home	222	2.8	1003	2.9	2.0	0.0
	2.14	Anything else	133	1.7	1118	3.2	855	4.9
Total complex chains			1904	23.9	7448	21.6	1446	8.2
<b>Total completed chains</b>			<b>7967</b>	<b>100.0</b>	<b>34496</b>	<b>100.0</b>	<b>17602</b>	<b>100.0</b>

Note: \* from Strathman, Dueker, and Davis (1994)

Table 3 must be examined with care. Attempt to compare specific chain patterns makes it difficult to categorize and compare all possible chaining patterns. Many of scarce sequences are hence required to group as "Anything else". As a consequence,



the Table should be used only in comparing each chain patterns among different areas. The ratio of simple to complex chain is valid, but the ratio of work and non-work chains in the complex chain is misleading since many of them are not categorized in the groups.

Greater Bangkok has a significantly high percentage of simple chains than the other countries, making up 91.8% of total trips. In Portland and Netherland, the simple chains constitute 76.1% and 78.4% of total travel. The simple chains in Bangkok are dominated by work and school trips and have comparatively fewer trips in other categories, especially social/recreational tours. The home-work-home and home-school-home chain account for 87.6% of the simple chain travel (54.2% in Portland and 30.0% in Netherland). It is noticed that the social/recreational travel in Netherland is relatively large or 26% of total trips.

With the Greater Bangkok data from Table 2, the differences in proportion of work and non-work trips in three countries are discernible. Work trips accounts for a small proportion of total trips in the Netherland (19.5%), but very large in Greater Bangkok (61.2%), and middle value in Portland (31.5%).

The percentages of work trips in complex chains are also distinct. The percentage complex chains in Greater Bangkok related to work (Table 2) is 74.5%. The figures are 26.8% in Portland and 19.4% in Netherland.

Considering the likelihood of chaining by purpose of travel, the both work and non-work travel in Bangkok is less prone to be chained. Complex chains are only 9.7% of work trips and 5.5% of non-work trips. In the other countries, percentages of complex chains in work and non-work category are similar and range between 20.5% and 25.5% of total trips in each category.

#### 5.4 Temporal Distribution of Trip Chaining

In consideration of work-related trips, the relationship between trip chaining during two rush hours and number of stops are found and illustrated in Table 4.

**Table 4. Number work trips in rush hours by number of stops**

Number of stops in a tour	Work trips			
	Morning (6-9am)		Afternoon (3-7pm)	
	No. of trips	Percent	No. of trips	Percent
0	6435	74.7	5516	81.3
1	1764	20.5	1048	15.5
2+	410	4.8	218	3.2

In the morning and afternoon normal rush hours, where most of trips are made, 8609 stops are made in the morning and 6782 are made in the afternoon. Work trips are chained to other activities in the morning more than in the afternoon (25% vs. 19%). Moreover, many trips in the morning are made with two or more stops. Statistical test

shows that the difference in number of chained trips during two time periods is significant at 99% level of confidence.

### 5.5 Purpose of Stops

**Table 5. Number of chained trips by purpose of stops**

Purpose of stops	Morning		Afternoon	
	No. of trips	Percent	No. of trips	Percent
Bangkok				
Shopping	3	0.3	14	2.4
Serve passenger	253	23.3	71	12.3
Serve students/kids	19	1.7	11	1.9
Personal business	1	0.1	5	0.9
Others	810	74.6	474	82.4
Vicinity				
Shopping	2	0.5	5	0.7
Serve passenger	201	46.9	72	10.4
Serve students/kids	20	4.7	7	1.0
Personal business	4	0.9	4	0.6
Others	202	47.1	603	87.3

As shown in Table 5, the majority of the purpose of stops (or the purpose of travel to destinations) are recorded as "Others". This is a major problem in this analysis since the purpose of trip is rather a difficult question to answer or unwilling to be answered by most people. Disregarding the others category, however, the serving passenger constitutes the main purpose of stops, both in the morning and in the afternoon. It is very suspicious that the "serve passenger" category is difficult to define and interpret and the number may be biased if the respondents are professional drivers such as taxi chauffeurs. Serving passenger occurs more in the morning than in the afternoon. This activity occurs more in the vicinity than in the center city.

The data shows that there are few shopping stops both in the morning and in the afternoon or less than 1% of total trips. This is also another suspicion since the afternoon shopping is a common custom for many people. This might indicate a source of errors in the data coding or the shopping stops have been included in "Others" purpose.

### 5.6 Mode Use in Relation to Stops

Data in Table 6 reveal that people who travel with public transport are more likely to chain their destinations into a tour than private auto users. They also on average have more stops in their tours. This finding is logical in that travel with public transport makes it easier to complete many activities in one tour since many travels involve with transfer at one or more stations. However, the results cannot be used to justify type and importance of the stops made by both groups. The table also shows that a higher percentage of travelers links their destinations in the morning than in the afternoon. This is contradictory to the general belief that people would have more activities and/or create more multi-destination links in the afternoon travel. The



number of stops of those who lives in the vicinity is higher than those of who live in Bangkok, the difference is observable especially in the morning for those who take public transport.

**Table 6. Number of stops in work trips by mode and gender**

No. of stops	From home-to-work (6-9am)				From work-to-home (3-7pm)			
	Public Transport		Private Transport		Public Transport		Private Transport	
	Male	Female	Male	Female	Male	Female	Male	Female
<b>Bangkok</b>								
0	57.5	55.3	83.9	84.9	66.0	62.7	92.1	88.8
1	34.1	35.0	15.0	14.0	28.2	29.6	7.2	9.5
2	6.4	7.8	0.8	1.0	4.7	6.9	0.7	1.6
3+	2.0	1.9	0.4	0.0	1.2	0.9	0.0	0.0
Average	0.94	0.94	0.41	0.35	0.84	0.88	0.26	0.33
<b>Vicinity</b>								
0	50.3	53.9	87.7	91.4	59.7	56.4	93.2	92.7
1	36.3	35.3	11.4	8.5	30.7	36.2	6.4	6.2
2	10.8	9.4	0.8	0.1	8.5	6.5	0.4	1.1
3+	2.7	1.4	0.1	0.0	1.1	0.8	0.0	0.0
Average	0.97	0.87	0.30	0.27	0.94	0.90	0.23	0.27

### 5.7 Gender and Trip Chaining

Table 6 also shows the relationship between gender and trip chaining. Women chain their activities less than men in the morning. On the other hand, women tend to link their destinations in the afternoon trips more than men. The only exception is the female public transport riders in the vicinity, their return trips being chained less than male of the same category. Women tend to have more social and recreational activities in the afternoon than men. These results are significant at 99% confidence level.

### 5.8 Geographical Area and Stops

Table 6 gives no noticeable relationship between the number of stops and residential locations. On average, travelers from/to the vicinity have higher average number of trips per person than Bangkok travelers. People from vicinity who travel by private cars have fewer number of stops than people originated in Bangkok. In contrast, public transport riders from Vicinity tend to have greater number of stops, with the exception on the female riders in the morning.

### 5.9 Duration of stops

Table 7 exhibits the percentage of number of trips by duration and purpose of stops. The time spending at destinations in complex work trips varies by purpose of stops. The shopping stops consume the longest stop duration or approximately 45 minutes. The time is slightly longer in the afternoon. Approximately 90% of stops for serve-passenger and school purposes has less than 5 minutes of duration at the stops. Bangkok and vicinity residents' behaviors are slightly different in the time usage. The

discernibly different duration of stops is in serve-passenger and school categories, where people who live in the vicinity spent less time for these purposes than Bangkok residents.

**Table 7. Duration of stops by purpose of travel**

Purpose	Duration of stops (minutes)				Average
	0-5	6-15	16-30	> 30	
Bangkok					
Serve Passenger					
from home to work	88.4	10.0	1.6	0.0	5.03
from work to home	77.1	14.3	5.7	2.9	8.70
Others					
from home to work	74.1	22.0	3.3	0.6	6.89
from work to home	81.3	16.1	2.2	0.4	7.81
Shopping					
from home to work	0.0	33.3	0.0	66.7	40.17
from work to home	7.1	0.0	42.9	50.0	43.85
School					
from home to work	72.2	22.2	5.6	0.0	5.00
from work to home	36.4	45.5	9.1	9.1	14.55
Vicinity					
Serve Passenger					
from home to work	97.5	2.5	0.0	0.0	0.94
from work to home	90.3	8.3	1.4	0.0	9.94
Others					
from home to work	78.5	17.3	3.7	0.5	6.98
from work to home	82.8	15.0	1.2	1.0	5.01
Shopping					
from home to work	0.0	0.0	0.0	100.0	41.11
from work to home	0.0	0.0	80.0	20.0	60.25
School					
from home to work	97.4	2.6	0.0	0.0	0.95
from work to home	100.0	0.0	0.0	0.0	4.12

## 6. POLICY IMPLICATION TO THE FINDINGS

The findings of the research serve for several purposes, ranging from the deeper understanding of the travel behaviors to the better utilization of the existing travel data for transportation demand analysis and planning applications. The characteristics of trip chaining patterns in the aggregate view reveal the magnitude of each travel type by different classifications and, consequently, implication of transport policy may be sought.

Majority of the total travel is made in one tour. Thus, the excessive person travel (or vehicle-kilometer of travel), by reason of multi-tours, is not a critical issue for current Bangkok travel.

The chaining of the trip may be viewed as the minimization of time budget. The chained trips are ordinary in Bangkok, although the results show that a significant amount of trips are made by simple trips. The stops in chains reflect necessary activities to be completed and could not be considered the possibility to reduce them with this analysis. Furthermore, impact of non-work complex chains would not be significant, compared to other countries, since the number is very low.



A uniquely large number of simple chains in Bangkok implies the potentiality to provide a mode for simple chains of urban travel. Roughly speaking, public transport and paratransit is suitable, and more comparable to auto travel, for single destination more than multi-destination travel since it would not consist of unneeded attributes such as transfer time, although it may be easier to have more activities (destinations) in a single tour at "necessary" stops. Thus, a provision of such public transport or paratransit, such as ride sharing, would serve these kinds of trips. Subscription buses and school buses may be arranged for a large share of simple work and school travel. The provision is possible due to not only the concentration of demand for the destinations but also the nature of the simple trips to those destinations.

Other policies aimed at reducing automobile trips, by diverting drivers to transit, can be considered, although their effectiveness may not be fully realized. This is because the findings show that a proportion of the travel has involved carpooling. A proportion of people do not drive alone throughout the chain, but pickup and dropoff others. Pushing drivers to transit may not reduce total trip making for those who already share rides or serve passengers. However, a large percentage of the drivers is still drive for single destination (Table 5). This kind of travel can be targeted to be replaced by public transport.

The incentive on public transport and paratransit would not only serve the simple trips but impact the complex travel. Provided existing riders switch to public transport, it would reduce the number of complex chains for those who serve passengers and serve students/kids by reducing the destinations of travel, eliminating stop time, shortening their trips, and, as a consequence, reducing vehicular travel. This may in turn reduce the congestion on streets, especially in the morning when the dropoffs mostly occur.

## 7. FUTURE WORK

The paper demonstrates the analysis of trip chaining patterns and the implication from aggregate travel examination. The investigation reaches some limitations on ability to explain individual travel behaviors and trip decision structure. An activity-based approach, which examines travel in disaggregate fashion, may be used in the trip chaining analysis. Study on individual and household attributes gives the better understanding on the trip making. Micro-analysis on trip attributes unveils the travel decision based on detailed approaches such as time-space budget. The disaggregate exploration from the household survey is possible, but may require further research support.

The analysis can be moved forward to construct more realistic trip chaining model. Recent attempts apply demand analysis techniques such as structural models, utility maximization, statistical analysis, and simulation to improve model validity and incorporate trip chaining into consideration. Trip chaining, if completely understood, can also be generalized in the demand analysis practice.

## 8. CONCLUSION

Trip chaining in Bangkok is studied from available household travel survey data. The database is created by linking all parts of travel into trip chains. Data analyses provide an insight into nature of chained trips. Several characteristics of trip chaining are disclosed. Trip chaining pattern in Bangkok is found different from other countries. It is found that simple chains hold a majority of trip in Bangkok. The study on attributes of chained trips and activities at travel terminations disclose the distinct trip types involved in various chaining patterns. The findings imply the application on policies pertaining travel demand. The knowledge of how travelers select their chaining decision is helpful and conveys better understanding in travel behaviors. The travel demand, therefore, can be modeled with realistic nature of travel.



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