Household Car and Motorcycle Ownership and Transaction Behavior through a Life-Course Approach - a Case in Taipei City

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Abstract: One of the most pressing problems in today's urban transportation environment is the ever-increasing number of private motor vehicles. To tackle this problem, many researchers start looking for factors that lead to travel behavioral changes. While most early studies in Taiwan take a cross-sectional approach and show a somewhat inconsistent result regarding the relationship between car and motorcycle ownership, this study assumes, arguably, that a longitudinal approach is necessary for better understanding of the problem. Based on empirical results of longitudinal analyses, this study finds that: 1) there is a positive association between life stages of honeymooner and crowded nester and the alternative of increasing a motorcycle; 2) the experience of exposure to motorcycle early in life have a positive effect on motorcycle acquirement and motorcycle replacement decision later in life; 3) households already owning motorcycle(s) are more likely to buy a car.

Keywords: Life-Course Events, Life-Style, Longitudinal Analysis, Household Car and Motorcycle Ownership

1. INTRODUCTION

One of the most pressing problems in today's urban transportation environment is the ever-increasing number of private motor vehicles. Over the past four decades in Taiwan, the number of cars has increased 365 times, from 18,000 in 1966, to over 6 millions in 2008, while the number of motorcycles has increased 154 times, from 92,000 to over 14 millions. Like many other countries, where motorization is closely related to economic growth, the increase of private motor vehicles in Taiwan has also been accompanied by significant growth of the economy. During the same period, GDP per capita of Taiwan has increased 69 times, from US$248 to US$17,399.

Before the development of mass rapid transit system back in the 1990s, people in Taipei metropolitan area (TMA) had no transit alternatives but bus that ran all over the city and also across adjacent areas. Currently, the main transit system in TMA consists of a network of Mass Rapid Transit System (MRT) and numerous bus lines. The daily average number of bus passengers has been stagnant over the years, while the daily passengers of MRT have

increased tremendously since opening of first line in 1996. Although the total share of public transit has been on the rise, whether there is an effect of cannibalism between MRT and bus remains open to discussion (Figure 1).

In spite of significant progress in transit development, however, the number of motor vehicles has continued to grow over the years. With this historical context, a longitudinal approach that explores household vehicle ownership over a long period of time thus seems necessary for investigating the complexity behind Taiwanese people's behavioral adjustments to those institutional and environmental changes.

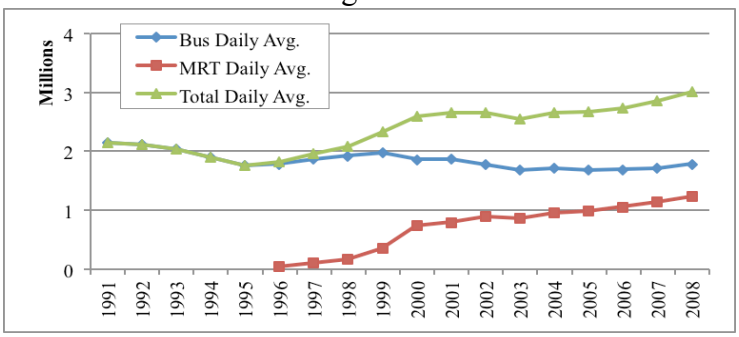

Figure 1 Average Numbers of Passengers of MRT and Bus in Taipei City
(source: DOT, Taipei City Government)

The objectives of this research are:

1. to improve understanding of the relationships between life stages and household vehicle holding and transaction behavior; and
2. to shed light on the longitudinal relationships of holding behavior between car and motorcycle from a life course point of view.

2. LITERATURE REVIEW

2.1 Vehicle Ownership in Taipei City

Vehicle ownership studies in Taiwan often take both car and motorcycle into consideration, as the latter is a commonly used mode in Taiwan. While Taipei City has the lowest number of motorcycles per 1000 people among six major cities in Taiwan, that is still one and half times more than the number of its cars (Figure 2).

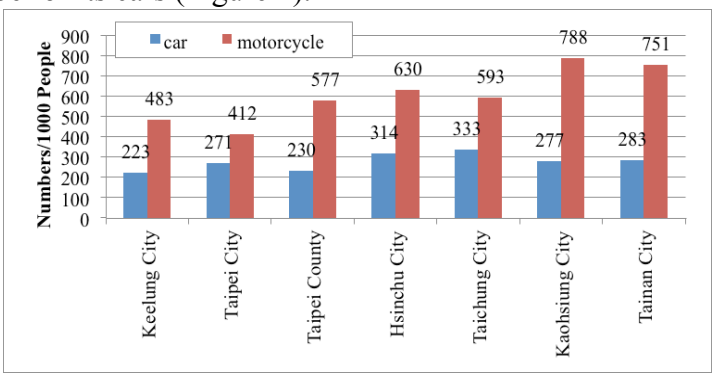

Figure 2 Vehicle Ownership in Major Taiwanese Cities in 2009
(source: Institute of Transportation, MOTC Taiwan)

In a nation-wide survey conducted by the Ministry of Transportation and Communication (MOTC) of Taiwan in 2008, 89.7% of the sampled households reported ownership of motorcycle, and 75.5% of them reported ownership of both car and motorcycle. Table 1 shows the modal split for daily and regular activities, such as commuting to work and school, shopping and errands, driving kids, medical services, etc.

Table 1 Travel Modes Used for Daily and Regular Activities (MOTC, 2008b)

Mode	Motorcycle	Car	Walk	Bicycle	Bus	MRT	Railway	Taxi	Others
Percentage	53.0	35.8	7.3	6.0	5.6	4.8	0.7	0.4	0.3

Note: multiple choices allowed up to three

The preference for motorcycle and car over public transit and non-motorized modes is not only strong nation-wide. Within Taipei metropolitan area (TMA), where public transit is relatively complete and accessible, motorcycle and car trips still account for 58% of all trips, according to Chang and Guo's study (2007). The ten most frequent types of trips are listed in Table 2. Noticeably, motorcycle is the most frequently used mode in both studies.

Table 2 The Ten Most Frequent Types of Trips by Travel Mode (Chang and Guo, 2007)

Rank	Trip Type	Percentage
1	Motorcycle	30.98
2	Car	27.23
3	Bus	14.34
4	Taxi	8.18
5	MRT + Transfer: Walk – Walk	5.80
6	MRT + Transfer: Bus – Bus	2.41
7	MRT + Transfer: Walk – Bus	1.39
8	MRT + Transfer: Bus – Walk	1.23
9	MRT + Transfer: Motorcycle - Walk	0.75
10	MRT + Transfer: Motorcycle - motorcycle	0.61
	Total	92.92

Despite its dominance, Taiwanese government once thought that motorcycle is "a transport mode in a transition from bicycle society to automobile society", and the number of motorcycles will shrink as the economy grows and number of cars increases (Chen, 2001). As a result, the policy on motorcycle management has only received limited attention in the past and it has led to various consequences, such as insufficient parking space, illegal parking on arcade space or fire lane, and high percentage of road accident.

Furthermore, the dependence on private motor vehicles, while difficult to measure, is also not easy to change. In the same survey by MOTC (2008), the households were asked whether they have changed travel mode for daily and regular activities two months after the then oil price surge in 2008[i]; only 17.3% of the respondents reported change of mode, among which 33.8% of the change were from car mode, and a mere 10.2% were from motorcycle mode. Of the 33.8% of car users, over 80% made their change to motorcycle, probably due to motorcycle's low economic costs and car-like speed and accessibility. Furthermore, the

respondents were asked to state their willingness to change in near future if oil price had risen another 30%. The result: 70% of Car users stated that they wouldn't change, while 75% of motorcycle riders said they wouldn't change.

Obviously, there is some kind of *behavioral inertia* that was working against the economic disincentive of oil price surge. It could be due to high transaction costs and risks the households would have to deal with if they had decided to respond to the uncertainty of oil price fluctuation by disposing their vehicles. It is this kind of behavioral inertia that continues to make the households feel committed to the vehicles of their possession. In other words, economic ability is an enabler, but not a motivator, of *vehicle dependence*.

In tackling the problem of car dependence, Goodwin (1995) proposed that there is a need to examine people's behavior over time.

> The idea of car dependence at a point in time is almost meaningless. The concept can only be addressed in terms of change over time, as constraints intensify or relax, and different dimensions of behavioral change are considered (p. 151).

2.2 Economic Relationship between Car and Motorcycle Ownership

The economic relationship between car and motorcycle ownership is a difficult one. If the two modes serve similar functions of households, obviously, they are more likely to be substitutes. If the two modes fit in to different needs of households, then they will tend to be complements. Consequently, understanding household characteristics and travel needs plays an important role in disentangling the complex relationship between car and motorcycle. While internationally the relationship between car and motorcycle ownership has received little attention, partly because motorcycle is a less popular mode, it is a major dispute in the Taiwanese literature.

As shown in Table 3, it seems that an agreement has yet to be reached. In the most recent study, Lai and his colleagues (2006) included the number of motorcycles in car ownership model and concluded that the relationship is substitute and insignificant; that is, the sign of the coefficient was negative, and the *t*-value was only mild. The authors then suggest that due to the unique strengths and weakness of car and motorcycle, perfect substitution is unlikely to be the case. Depending on trip purposes and distances, Taiwanese people might choose different modes to travel.

Table 3 Previous Studies Regarding Relationship between Car and Motorcycle Ownership in Taiwan (Lai et al., 2006)

Relationship Between Ownership of Car and Ownership of Motorcycle	
Substitution	**Complementarities**
(Chen, 2002) (Chang 2003) (Zhou et al, 2004) *Substitute but not significant* (Lai et al., 2006)	(Liao, 1996)

2.3 Life-Style & Life-Course Approach

Household travel needs change along with household characteristics, which vary with household *life stage* and other socioeconomic characteristics. To fulfill its travel needs, the household makes a choice out of available alternatives under a set of constraints imposed by transportation environment and own capability or resources. As a result, household travel needs do not stay unchanged as time goes by; the decision making process is a dynamic process that continues to evolve over time. In another word, new needs emerge and old needs disappear, as the households go through different stages of life and as the transportation environment continues to offer new opportunities and reduce existing alternatives.

Life-style approach is a cross-sectional approach in which life-style is usually used as an integrated descriptor for market segmentation (Salomon and Ben-Akiva, 1982, 1983; Kitamura, 2009). On the other hand, life-course approach is a longitudinal approach in which different dimensions of life or trajectories are considered together with time axis included. Its focus is on the interactions between life-course events and changes in different dimensions of life.

To date, perhaps because motorcycle is not as popular internationally, most of the studies that take a life-course approach focus on car (Beige, 2008; Hanly and Dargay, 2000; Nolan, 2010). In Taiwan, although most studies consider car and motorcycle, the longitudinal approach has received only limited attention, in large part due to the unavailability of longitudinal data. As a result, this study aims to bridge the gap between the international focus and the unique mode choice set in Taiwan.

3. METHODOLOGY

3.1 Theoretical Framework

Based on the research objective and literature review described above, the authors proposed a theoretical framework for this study (Figure 3). From a transport planner's point of view, factors leading to travel behavioral changes deserve attention; especially changes in travel decisions with commitment or long-term and mid-term decisions, such as vehicle ownership and holding behavior. By definition, life style is an observable behavioral pattern and at the same time, it's an orientation that underlies behavior, so the effects between life-style change and travel behavioral change are potentially bidirectional. Besides, life style changes with institutional and technological change, life-stage change, and also changes in other socioeconomic factors. Previous studies pointed out that, family formation, participation in labor force, and orientation toward leisure, are three major dimensions of life style from which we can make some meaningful subgroups of travel patterns (Salomon and Ben-Akiva, 1982). Hence, key events in these three dimensions are defined as life-course events, which are assumed to have impacts on a household's life stage as well as other socioeconomic aspects.

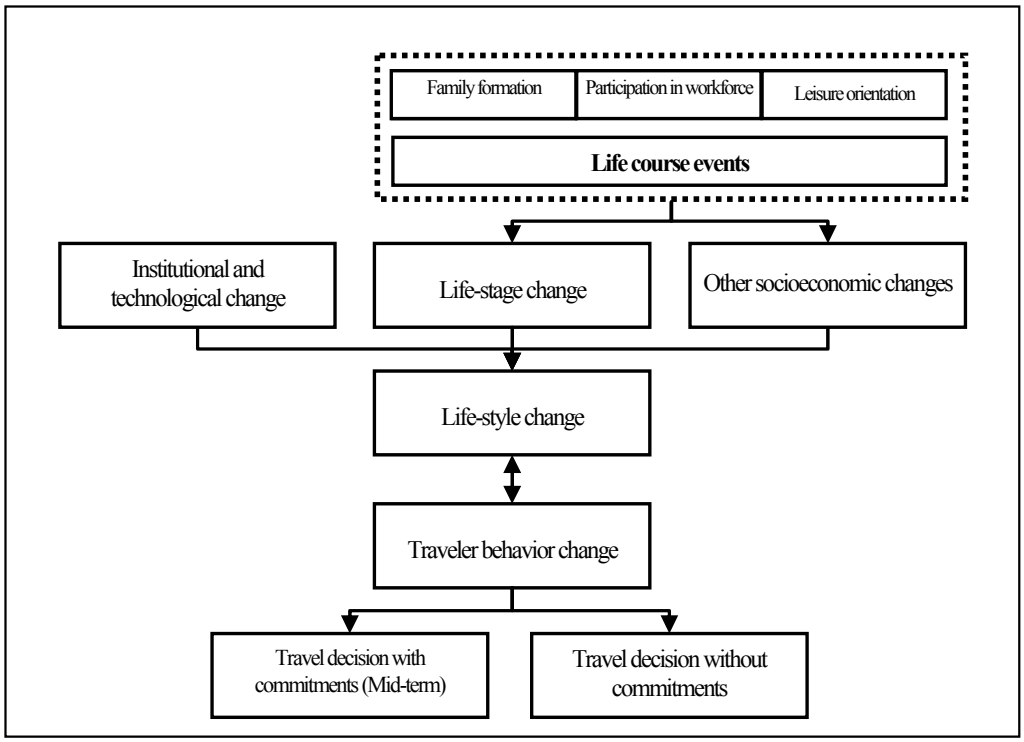

Figure 3 Theoretical Framework

3.2 Concept of Dynamic Modeling through a Life-Course Approach

Figure 4 illustrates the concept of dynamic modeling of household car and motorcycle transaction behavior and ownership through a life-course approach. As can be seen, household stages of life, motorcycle holding trajectory, and car holding trajectory can be seen as three parallel processes that are constantly evolving on the time axis. For example, the event of getting a motorcycle from parents as a present for coming of age, which is arguably a common custom in Taiwan, leads the household to acquire a new motorcycle, hence increasing the number of motorcycle from zero to one. Besides, the event of first childbirth causes the household to enter the life stage of New Parent. Within New Parent stage, the household decides to acquire its first car; the number of cars increases from zero to one.

The interrelationships between household life stages (as triggered by life-course events), motorcycle holding trajectory, and car holding trajectory can therefore be better understood, and because time axis is included, the causal relationship between events and mobility decisions can be better explained and interpreted.

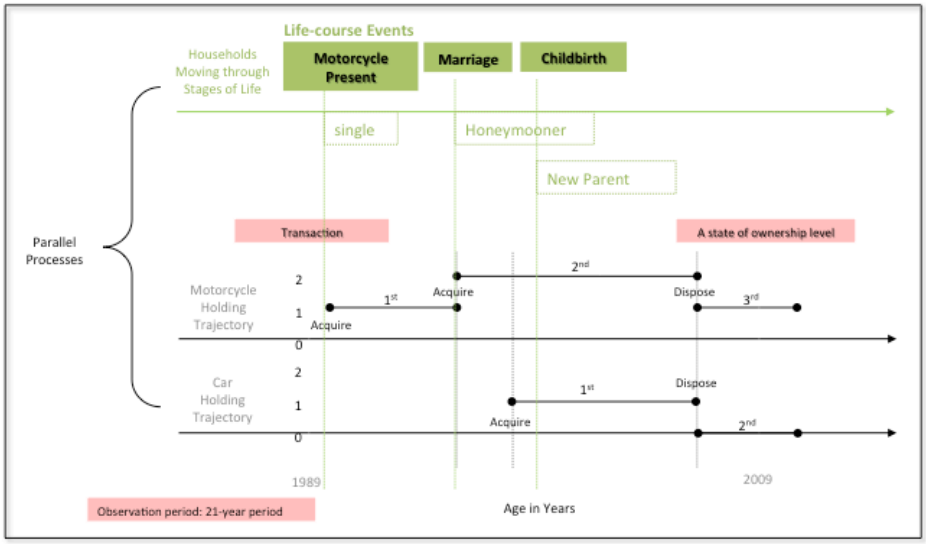

Figure 4 Concept of Dynamic Modeling on Household Car and Motorcycle Ownership and Transaction Behavior

3.3 Survey Design & Implementation

Observation window for the longitudinal data was set to be a 21-year period, from 1989 to 2009. The survey was carried out at a household level, i.e. under the assumption that long-term life-style decisions, and mid-term mobility decisions (or travel decisions with commitment) are reached under a single decision-making process in a household. Household is defined as an economically independent living unit, so individuals who 1) are above eighteen years old, and 2) are earning own livelihood, are potential samples. Since collecting 21-year historical information is highly time-consuming, some technique to help the households recall those decisions is necessary; a data collection method of retrospective interview was adopted with the assistance of *life-course calendar* (Freedman et al., 1988).

The survey was carried out in September 2010. Since it was an in-depth retrospective interview, it took around one hour for a household to finish, contingent on the volatility and stability of choice set the household had experienced over the life course up to the time of interview. In order to obtain data that are down to the details required for a longitudinal analysis, this study took the advantage of convenient sampling that enables just this purpose by targeting friends, relatives, and their colleagues. In addition, a chance of winning a local lottery was also provided as incentive.

Overall, a set of longitudinal data was successfully collected from a sample of 40 households. Not every household head was over 18 years old with economic independence in 1989. And since the data on household life course was only collected after the household head became 1) adult and 2) economically independent, the total cases or observations were summed up to 795 (i.e. Not every household had a full 21-year-period data span, some of them had 20-year span, some of them less. So total cases didn't sum up to 21 x 40 = 840).

3.3 Terminology

This section describes the definitions of terms used in the study. Life stages are defined based

on a previous study of automobile ownership duration (Gilbert, 1992), with minor changes adapted to the research objective and Taiwanese context:

1. Singe (S, SL1)[ii]: over 18 years old, economically independent, and not married.
2. Honeymooner (H, SL2): married without presence of children.
3. New parent (N, SL3): children present, all less than 7 years old.
4. Young family (Y, SL4): children present, some less than 7 and some between 7 and 17.
5. Full nester (F, SL5): children present, all between 7 and 17.
6. Crowded nester (C, SL6): children present, some between 18 and 24.
7. Empty nester (E, reference): no children present (all economically independent), or all older than 25 years old.

Household car and motorcycle transaction behavior is defined by four types of transactions a household choose to do with their car or motorcycle fleet upon each of the 21 decision-making points (each year in the observation window). The working definitions of transaction choices are as defined as follows:

1. Acquire (A): increase number of vehicles by one unit; upgrading mobility; the number of vehicles changed,
2. Dispose (D): decrease number of vehicles by one unit; degrading mobility; the number of vehicles changed,
3. Replace (R): replace an old vehicle with an new vehicle of the same type, i.e. replace an old car with a new car or replace an old motorcycle with a new motorcycle; maintaining mobility; the number of vehicles remains unchanged,
4. Do Nothing (N): do nothing on the fleet.

Beside, household heads having got a motorcycle present from parents (before they start working) is defined as household heads with *early exposure to motorcycle* (EEM). It's a common custom for children who just turned 18 years old to receive a motorcycle present from the parents.

Time order is defined as the order with which people acquire car and motorcycle; we assumed that households already owning motorcycle(s) are more likely to buy car, because of differences in the characteristics of the two modes.

4. DATA EXPLORATION & HYPOTHESIS CONSTRUCTION

4.1 Descriptive Analysis

Figure 5 shows an aggregate result that reflects, collectively, the time order in which life-course events took place in the sampled households. During the observation window, most of the time the households chose to do nothing with their fleet. The proportions of acquirement and replacement were much higher than disposals for both car and motorcycle (Table 4). This result corresponds to an earlier study in Toronto, Canada (Mohammadian and Miller, 2003).

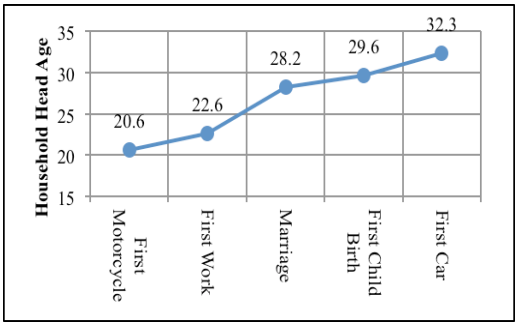

Figure 5 Average Age of Selected Life Course Events

Table 4 Count and Frequency of Transaction Choice

Motorcycle	Counts	%	Car	Counts	%
Acquire	49	6.16%	Acquire	33	4.15%
Dispose	12	1.51%	Dispose	8	1.01%
Replace	44	5.53%	Replace	43	5.41%
Do Nothing	690	86.79%	Do Nothing	711	89.43%
Total	795	100.00%	Total	795	100.00%

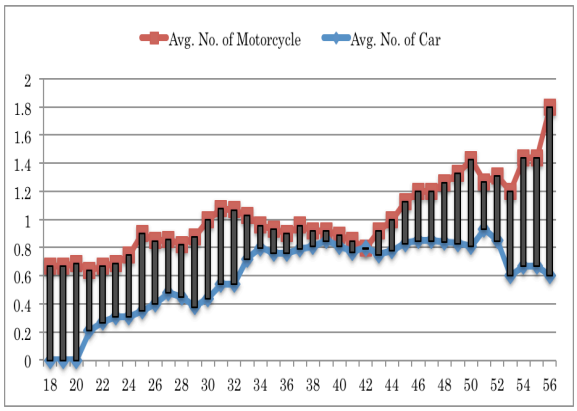

Figure 6 Numbers of Cars and Motorcycles by Household Head Age

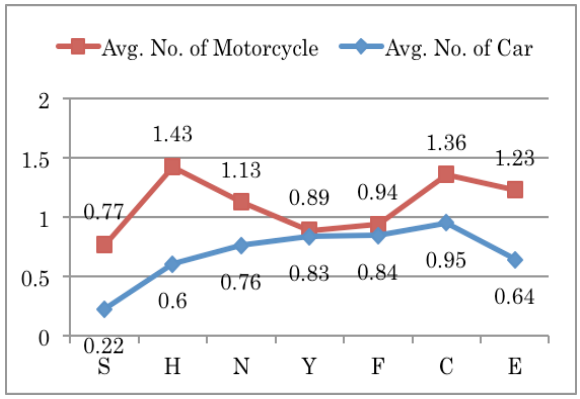

Figure 7 Numbers of Cars and Motorcycles by Life Stage

In addition, Figure 6 shows the relationship of the two modes; it was first complementary and then gradually evolved into slight substitution. If we see the numbers of cars and motorcycles by life stage (Figure 7), there were two peaks for motorcycle, at honeymooner (H) and crowded nester (C) stages; while the pattern in the number of cars looked like a monotonic growth toward older households.

4.2 Early Exposure to Motorcycle (EEM)

In this study, an important question is whether earlier exposure to motorcycle (EEM) leaves some impacts on vehicle transaction behavior later in life. And the required information was surveyed through the following questions:

1. Did you get a motorcycle as a present from parents?
2. Did you buy your children motorcycles after they became adult?

3. How often did your parents use car and motorcycle?

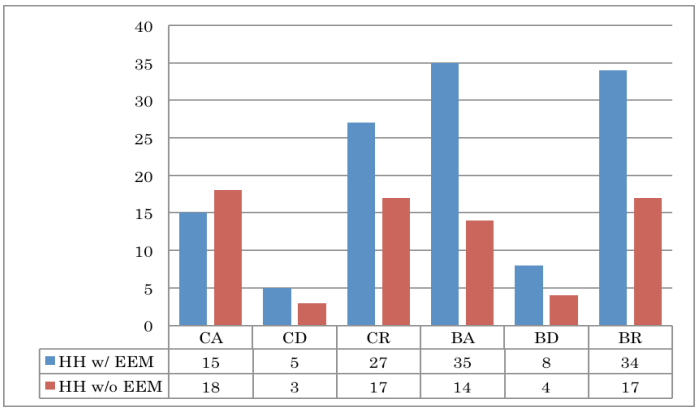

Figure 8 Counts of Transactions Types by Experience of EEM

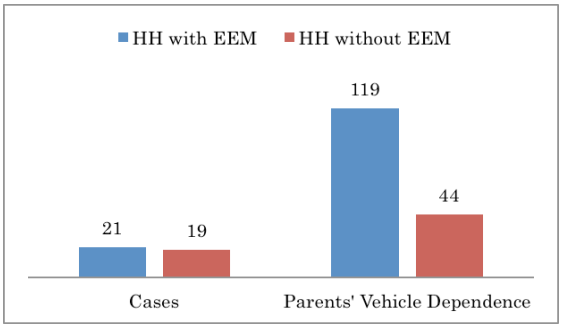

Figure 9 Parents' Vehicle Dependence and Experience of Early Exposure to Motorcycle (EEM)

	Avg. Age of Owning **1st Motorcycle**	Avg. Age of Owning **1st Car**
HH w/ EEM	18.7	27.2
cases	21	20
HH w/o EEM	29.7	31.3
cases	18	18

Table 5 Average Age of Owning First Motorized Vehicle

In the sample, more than half of the households had their first motorcycle as a present from parents (21 out of 40). In total, the household heads with EEM (HH w/ EEM; household heads who had experienced early exposure to motorcycle) gave higher scores on their parents' vehicle dependence (PVD)[iii](Figure 9). If the PVD were appropriately measured, it indicated that the parents that had used private motor vehicles frequently were more likely to buy their children a motorcycle present soon after they turned 18 years old (Figure 7). Furthermore, the household heads with EEM started to use motorcycle very early, while the household heads without EEM started to use motorcycle very late, more than a 10-year difference (Table 5). On the other hand, it took much more time for the household heads with EEM to acquire the first car than the household heads without EEM. Between the two groups, there seems to exist some differences in the households' preference over car and motorcycle.

In addition, household heads with the first motorcycle as present had higher frequencies of car replacement, motorcycle acquirement, and motorcycle replacement. This group of household heads had replaced both their cars and motorcycles more often (Figure 8).

4.3 Research Hypotheses and Models

To accomplish the research objectives, we constructed three research hypotheses:

1. RH1: Some specific life stages are strongly associated with certain household choice of vehicle ownership;
2. RH2: The experience of early exposure to motorcycle (EEM) has some effects on vehicle transaction behaviors later in life; specifically, household heads having got a motorcycle present early in life are more likely to conduct motorcycle acquirement, motorcycle replacement, and car replacement transactions later in life;
3. RH3: There is a time order with which households acquire car and motorcycle; namely, households owning motorcycle(s) are more likely to acquire a car.

To verify RH1, we inferred households' preferences over car or motorcycle through a dynamic model of household choice of vehicle ownership, specifically, a multinomial logistic regression model which can clarify the factors influencing probabilities of more than two discrete outcomes. The main explanatory variables, apart from common socioeconomic ones, included dummy variables that represent life stages and life-course events. For RH2, two multinomial logistic regression models were used for car and motorcycle transaction choice models. A dummy variable was added to identify if a household head had experienced EEM. Regarding RH3, we adopted a random effects ordered probit model, which is typically used to explain probabilities of ordinal choices, for modeling the dynamic car ownership. Dummy variables representing each level of motorcycle ownership were added.

5. EMPIRICAL ANALYSIS

5.1 Dynamic Model of Household Choice of Vehicle Ownership

Household vehicle ownership in time t can be seen as an aggregate result of several decisions the household has made up to the time t. Table 6 shows the choice set and proportions of alternatives. I specified the choice set as follows:

- Starting from current level of ownership (0), each household can choose one of the five directions to go (0, 2, 4, 6, and 8). Choices of diagonal directions were aggregated into other five directions due to a lack of cases[iv]. Choosing 0 means to stay unchanged with current ownership; choosing 2 means to increase one motorcycle and so on.
- The number of alternatives available to a household is conditional on vehicle holding level of the household. For example, if a household didn't own a car in a specific year, the household didn't have the alternative of disposing one.

Table 6 Choice Set of Household Vehicle Ownership

		Motorcycle	
	-		+
Car -	7	8 (1.0%)	1
+	6 (1.4%)	0 (origin) (87.7%)	2 (5.8%)
	5	4 (4.2%)	3

Table 7 Estimation Results of Household Choice of Vehicle Ownership Model

Alternative	Variable	Coeff.	t-statistic
Stay Unchanged (0)	Income	0.53*	2.46
	SL3	0.25	0.51
	SL4	0.58	0.90
	SL5	-0.22	-0.52
Increase a Motorcycle (2)	Alternative Specific Constant	-3.86	-5.71
	Income	0.32	1.25
	Secondary Worker Status	0.36	1.07
	SL2	3.07*	4.86
	SL6	2.33*	4.05
	No. of Pre. Motorcycle Replacement	0.28*	2.52
	Parents' Vehicle Dependence	0.19*	3.28
	No. of Motorcycle Last Year	-1.14*	-3.95
Increase a Car (4)	Alternative Specific Constant	-2.11	-2.86
	Parking Space	1.70*	2.35
	Income	0.88*	2.98
	SL1	-0.95	-1.52
	SL2	0.62	0.79
	SL6	-1.27	-1.09
	No. of Pre. Motorcycle Replacement	-0.42	-2.19
	No. of Car Last Year	-3.69*	-4.80
Decrease B (6)	Alternative Specific Constant	-2.73	-5.92
Decrease C (8)	Alternative Specific Constant	-2.52	-4.24
Output Statistics	No. Obs.	795	
	LL(0)	-403.35	
	LL(β)	-336.71	
	Chi-squared	149.88	

*Significant at 5% level

Table 7 shows estimation results of the model. The t-statistics for honeymooner stage (SL2) and crowded nester stage (SL6) were 4.86* and 4.05*. Except for honeymooner and crowded nester stages, the associations between life stages and vehicle ownership choice were not found to be significant. Honeymooner and crowded nester stages were found to have a significant positive association with "increase a motorcycle" alternative. Therefore, the null hypothesis that none of the life stages are associated with vehicle ownership choice was rejected. The reasons are rather straightforward: First, marriage does not only bring two individual persons together, but also brings their belongings together, which certainly includes motorcycle holdings. Second, in the survey, many household heads bought motorcycles for their children soon after their children turned 18 years old as a present for becoming adult. This result also explained the two-peak phenomenon of motorcycles ownership shown in Figure 6. In addition, the t-statistic for parents' vehicle dependence (PVD) was 3.28*, suggesting there is a causal relationship between PVD and household

head's decision on increasing a motorcycle; that is, household heads whose parents were of higher vehicle dependency are more likely to increase motorcycle ownership.

5.2 Dynamic Model of Vehicle Transaction Choice

This part deals with EEM's effect on car and motorcycle transaction choices separately, by modeling each mode with a multinomial logistic regression model. The choice set was specified as follows:

- Every household can make one transaction choice out of "acquire", "dispose", "replace", and "do nothing" upon each decision-making point
- The number of alternatives available to a household is conditional on the number of cars or motorcycles the household owns

Table 8 Estimation Results for Motorcycle Transaction Model

Alternative	Variable	Coeff.	t-statistic
Acquire (A)	Alternative Specific Constant	-4.33	-6.17
	Income	-0.24	-1.16
	No. of Adult	0.07	0.28
	EEM Dummy	1.19*	2.87
	Parents' Vehicle Dependence	0.10	1.75
	Marriage	2.77*	5.70
	Children Coming of Age	3.30*	5.46
	Entering in Workforce	2.69*	4.26
Dispose (D)	Alternative Specific Constant	-3.31	-4.62
	Income	-0.42	-1.47
	Presence of Car	0.68	0.97
Replace (R)	Alternative Specific Constant	-3.26	-5.59
	Income	0.07	0.46
	No. of Adult	0.10	0.56
	EEM Dummy	0.67*	1.96
Do Nothing (N)	Residential Location - Urban	-0.43	-1.10
	Residential Location - Suburban	-0.01	-0.03
	Residential Location - Rural	Reference	
	Motorcycle Transaction Within 3 Years	0.92*	3.56
Output statistics	No. Obs.	795	
	LL(0)	-390.36	
	LL(β)	-337.48	
	Chi-squared	140.46	

*Significance level at 5% level

Table 9 Estimation Results for Car Transaction Model

Alternative	Variable	Coeff.	t-statistic
Acquire (A)	Alternative Specific Constant	-2.70	-4.96
	Income	0.58*	3.04
	No. of Adult	-0.34	-1.39
	Parking Space	1.62*	2.19
	EEM Dummy	-0.06	-0.16
	No. of Car Last Year	-3.36*	-4.17
Dispose (D)	Alternative Specific Constant	-1.41	-1.60
	Income	-0.82*	-2.26
Replace (R)	Alternative Specific Constant	-2.69	-2.06
	Age	0.06	1.67
	1st Motor Vehicle Dummy (Motorcycle)	-0.78	-1.31
	No. of Adult	-0.72*	-2.38
	EEM Dummy	0.68	1.19
	Heavy User (SWS=1, SE=1)	0.82	1.80
Do Nothing (N)	Residential Location - Urban	0.39	1.11
	Residential Location - Suburban	-0.30	-0.60
	Residential Location - Rural	Reference	
	Car Transaction Within 3 Years	0.49	1.70
Output Statistics	No. Obs.	795	
	LL(0)	-311.84	
	LL(β)	-280.17	
	Chi-squared	126.73	

*Significance level at 5% level

After controlling for a number of socioeconomic variables, the t-statistics of EEM were 2.87* for motorcycle acquirement, 1.96* for motorcycle replacement, and 1.19 for car replacement. EEM's effect was found be significant for motorcycle acquirement and motorcycle replacement. The estimation results empirically verified that EEM has a positive effect on motorcycle acquirement and motorcycle replacement but not on car replacement. As a result, the null hypothesis that EEM has no effect on motorcycle acquirement and motorcycle replacement was rejected. That is, household heads that had received motorcycle present from their parents are more likely to acquire and replace motorcycle later in life. However, the null hypothesis that EEM has no effect on car replacement couldn't be rejected.

5.3 Dynamic Car Ownership Model

Car ownership refers to the number of cars owned by a household. Table 10 shows the counts and proportions of car ownership in the sample. Cases of two cars only represented around 5% of total cases. Dummy variables representing one motorcycle (NOMOTORCYCLEL1), two motorcycles (NOMOTORCYCLEL2), and three motorcycles (NOMOTORCYCLEL3) in last decision-making point were used to distinguish the effects of different levels of motorcycle ownership on car ownership.

Table 11 shows estimation results of the random effects ordered probit model. The model fit well. Among some basic socioeconomic variables: age, income, living in urban area, parents' vehicle dependency, number of previous car replacements were found to have significant positive association with the number of cars owned. Notably, household heads whose parents were of higher vehicle dependency are more likely to buy a car. On the other hand, secondary worker status and first motor vehicle dummy (motorcycle) were found to have significant negative association with the number of cars owned. The fact that a household head's first motor vehicle is motorcycle has a negative effect on car ownership decision.

The t-statistics for NOMOTORCYCLEL1, NOMOTORCYCLEL2, and NOMOTORCYCLEL3 were 4.06*, 2.86*, and -0.22, respectively; the former two were significant with the positive effect declining from one motorcycle to two motorcycles. Accordingly, the null hypothesis that the number of motorcycles last year has no effect on current car ownership decision was rejected for one motorcycle (NOMOTORCYCLEL1) and two motorcycles (NOMOTORCYCLEL2). However, for three motorcycles (NOMOTORCYCLEL3), it couldn't be rejected. The result indicates that households already owning motorcycle(s) (one or two, but not three) are more likely to increase the number of car (mostly moving from no-car household to one-car household), suggesting the existence of a time order with which households acquire car and motorcycle: they usually already own motorcycle(s) before acquiring a car.

Table 10 Proportions of Dependent Variables

No. Car	**Count**	**Freq.**
0	334	0.420
1	422	0.531
2	39	0.049
Total	795	1

Table 11 Estimation Results for Dynamic Car Ownership

Variable	**Coeff.**	**t-statistic**
Constant	-7.72	-8.46
Age	0.14*	4.47
Income	1.02*	6.34
No. of Adult	-0.29	-0.97
Residential Location - Urban	1.22*	3.23
Residential Location - Suburban	-0.24	-0.60
1st Motor Vehicle Dummy	-1.40*	-3.29
Secondary Worker Status	-0.59*	-3.57
Parents' Vehicle Dependence	0.33*	6.06
No. of Pre. Car Replacement	0.75*	3.26
No. of Pre. Motorcycle Replacement	-0.12	-0.81
No. of Motorcycle Last Year Dummy 1	1.02*	4.06
No. of Motorcycle Last Year Dummy 2	0.99*	2.86
No. of Motorcycle Last Year Dummy 3	-0.38	-0.22
Threshold parameter for index		
Mu(1)	8.23	8.42
Std. Deviation of random effect		
Sigma	2.30	11.19
Output statistics		
No. Obs.	795	
LL(0)	-435.36	
LL(β)	-269.02	
Chi-squared	332.67	
*Significance level at 5% level		

6. CONCLUSION

The empirical analysis verified the three research hypotheses. First of all, the positive association between the life stages of honeymooner and crowded nester and the alternative of increasing a motorcycle were verified and interpreted.

Second, we found that the experience of early exposure to motorcycle has a positive effect on motorcycle acquirement and motorcycle replacement decision later in life: household heads having received a motorcycle present from parents are more likely to acquire motorcycle(s) later in life. Those motorcycle acquirements were primarily done for their children, according to the data and reasons for changes of vehicle ownership cited by the households. Namely, household heads with early exposure to motorcycle are more likely to give their children the same early exposure, forming an *intergenerational effect* of motorcycle experience. This might explain, partly, why over the years, the number of motorcycles have continued to grow in spite of rapid economic growth and significant progress in transit development.

Finally, the effects of motorcycle ownership on car ownership were also supported: households already owning motorcycle(s) are more likely to buy a car. From the data set, we know it means that households owing one or two motorcycles at hand are more likely to increase a car (moving from no-car household to one-car household, which is very likely the first car in life for the household). Thus, this study verified the existence of a time order with which households acquire motorcycle and car.

Life-course approach is a longitudinal approach that opens up new perspective on the effects of past events on car and motorcycle ownership decision, such as parents' vehicle dependency and the type of first motor vehicle. This approach also defines many time points of potential behavioral change that offers policy makers more tools with which they can promote socially desired behavior. The experience of early exposure to motorcycle, does not only have an effect on the receiving household head himself/herself, but also likely leave an impact on their children. So addressing the problem of car and motorcycle ownership as early as possible in people's life course is therefore very critical to preventing further development of a car/motorcycle dependent society.

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[i] As a result of global price surge of crude oil back in 2008, gasoline and diesel prices in Taiwan had increased from 26.45 (NTD/l) in Jan 3, 2007 to the peak of 35.65 in Jul 2, 2008, a 35% jump.

[ii] (S, SL1) = (acronym in Figure 6, dummy variable in Table 7)

[iii] Parents' vehicle dependence (PVD) was measured by asking the respondents to recall their parents' main travel mode for ten different scenarios, varying mainly in purpose and distance, like "going to restaurant with family" or "commuting to work", and the choice results were then summed up. This score tends to see that out of the ten travel scenarios, how often the parents used motorcycle and car, based on the children's memory.

[iv] There was one case of increasing a motorcycle and decreasing a car choice (1), three cases of increasing a motorcycle and increasing a car choice (3), and one case of increasing a car and decreasing a motorcycle choice (5). Decision related to car is considered as the more important decision due to its much higher cost so (1) was integrated into (8), (3) into (4), and (5) into (4).