CHAPTER 6   DISCUSSION

A research design, combining the MOTC's sampling inventory for motorcycle usage with the VRS records, was developed and used in this study. The motorcycle ownership duration and disposal age of these sampled observations were observed by tracing the motorcycle registration records. To correct the heterogeneity of the censored observations that cannot be considered by the conventional duration models, a split-population duration model with a Weibull hazard function was employed. In addition, logistic regression models were separately established to explore the odds in holding a used vs. new motorcycle and in ending a motorcycle holding by a disposal vs. transfer event.

Four parts of this study are discussed: comparisons of the estimated holding duration and scrappage age, associations for independent variables with hazard rates and odds ratios, policy implications, and the limitations of this research.

6.1 Estimated Holding Duration and Scrappage Age

Holding duration of a motorcycle is less than its scrappage age because a holder may own a second-hand motorcycle at the initial holding and end his holding by transferring but not by disposing of it. Without inclusion of the censored observations, the pooled mean holding duration by combining disposal events with transfer events was around 8.75 years, while the ownership ended by disposals was 11.04 years and by transfers was 6.98 years, during around four-year observation period. The duration difference between these two competing events indicated that the disposals had around 4 years more than the transfers. Since the coefficient of variation for the transfer events (0.74) was higher than the disposal events (0.48), the holding duration ended by a transfer appears to spread wider.

In terms of motorcycle scrappage age, however, the mean age was about 13.3 years. Around 30% of the sampled holders owned a used motorcycle, and of the used motorcycles at the initial holding, the average age was 5.69 years. In addition, the median years were lower as compared with the corresponding mean values for both holding duration and disposal age. For example, the median for pooled holding duration was 7.52 (mean = 8.75) and for disposal age was 12.99 (mean = 13.30). This represents

both of the duration variables concerned had a distribution skewed to the right.

The mean age of motorcycle in-use was 8.1 years of the overall sampled motorcycles in Taiwan at the start of this study (December, 1999), while in Taipei city, the active mean age at the end of 2005 was estimated at 7.8 years using a motorcycle age distribution registered in Taipei city. The active mean appears to be higher than Bangkok (4.5 years), comparable to Victoria (7.6 years), and lower than state of Taxas (9.5 years) (UNDP & ESMAP, 2003; Road Safety Committee, 1993; Office of Vehicle Fleet Management, 2005). However, motorcycles comprise two-thirds of the vehicle fleet in Taiwan, obviously higher than other countries, so either a higher active mean age or scrappage age of motorcycles should be put much attention because older motorcycles produce more energy consumption and emissions problem.

Compared with the results from other domestic studies, the disposed mean age in this study is higher than the estimated value from ITRI (2002) and Lu and Lee (2001). ITRI (2002) reported a mean of 11 years from the records in the VAMR program that promotes owners to scrap their older motorcycle, while Lu and Lee (2001) estimated a 10.44 years from a mathematical equation. Part of the discrepancy may result from the different samples and method applied. ITRI used motorcycles in-use aged more than 7 years attending in the VAMR program to estimate the lifetime of scrapped motorcycles. Lu and Lee, however, used the motorcycles in-use age distribution from the VRS records, then transformed them into a not-in-use proportion by age, and estimated the scrappage age. The mean motorcycle lifetime from ITRI appears to be lower than our results by 2.3 years, possible resulted from the cash incentive inducing owners to scrap older vehicles sooner. However, the effectiveness of the VAMR still needs more detailed examinations.

On the other hand, the expected remaining use years (5.2) self-reported by the respondents from another survey (MOTC, 2002b) appeared consistent with this study after motorcycle scrappage age (13.3) deducting the current-in-use age (8.1) at the time of sampling. Unfortunately, no population-based statistics for motorcycle scrappage age can be available from any of the official reports, and thus it appears not possible to judge the precision of the diverse estimated results.

However, no matter which result predicts better, a big proportion of older motorcycles makes the emissions problem worse and displays a disproportionately high ineligibility rate. Motorcycles aged ten years or more had more than 3 times the rejection rate as compared with motorcycles aged less-than-three years in the annual

inspection (EPA, 2005), even though older motorcycles only have to comply with loose standards dating from their year of manufacture.

As for the duration modeling part, limited by the four years observation period, censored observations made up 70% for estimating pooled holding duration and 88.5% for scrappage age. Mean holding duration for censoring (10.39 years or more) was greater than the event mean (8.75 years), meaning that some censored observations may be delayed in experiencing a disposal or transfer record possibly due to the unfinished registration status. The inclusion of these censored data inflated the estimated median holding duration to 14.62 years (i.e. 7.61 years for only event data considered) using a parametric duration model following a Weibull hazard function. The median reduced to 12.33 years after correcting by a split-population method and around 21% of the samples that might never experience events was estimated. For the disposal age part, only event observations showed an estimated median age of 12.91 years. After taking into account the censored data, the estimated median age increased to 20.89 years. The median time further declined to 15.94 years after the inclusion of a split-population method and around 47% of the samples were split into a proportion that never experienced events.

Even though the split-population method was applied, the estimated median holding duration increased by about 5 years (=12.33-7.61) and the median scrappage age by about 3 years (=15.94-12.89) as compared with event data only. This may arise from the relatively huge proportion of censored data, in which their events cannot not be followed up due to the limitation of the observation period. The large proportion of the censored data may reduce the statistical efficiency, although the split-population method has eliminated specific samples of never experiencing events. Therefore, to increase the precision of the estimated survival time, the observation period is suggested be prolonged.

6.2 Association of Hazard Ratio and Odds Ratio with Determinants

6.2.1 Association of Hazard Ratio

The independent variables for three types of duration models associated with hazard ratio of the events are summarized in Table 18. According to the attribute

categories, each variable is discussed across the different types of models.

1. Vehicle attributes

(1) Used motorcycle

Holders possessing used motorcycles increased the hazard not only for their holding duration but also for the overall motorcycle scrappage age, leading to a shorter time for the ownership and disposal age. The positive relationship with holding duration was in accordance with the past studies on automobiles (De Jong, 1996; Yamamoto and Kitamura, 2000). De Jong (1996) indicated that this relationship resulted from the lower reliability and higher repair cost of a used car. The overall scrappage age shortened by a used motorcycle, however, may have the similar reasons.

The hazard ratios by disposals appear higher than by transfers in terms of holding duration. It might be the case that a used motorcycle was likely to speed up the decrease in the residual value of the motorcycle as compared with a new motorcycle purchased, hence a used motorcycle had a higher likelihood of being disposed of than being transferred.

(2) Age of motorcycle purchased

Interestingly, the age of motorcycle purchased at the initial ownership had different directions affecting the following holding duration and the overall scrappage age. Consistent with the holding duration for automobiles (De Jong, 1996; Yamamoto and Kitamura, 2000), the positive association between the age of a motorcycle at purchase and the hazard of ending its ownership was also proved. However, the more the vehicle age at initial holding, the less the hazard for the motorcycle being disposed of. This means a holder possessing a used motorcycle with greater age would extend the overall motorcycle lifetime. The reason might be an individual who bought a more aged motorcycle has a lower frequency of use so that the overall disposal age increases. It should be noted that on average, as pointed out by the previous variable, these used motorcycles still had a shorter life span than new motorcycles purchased.

(3) Engine Size

Compared with engine capacity greater than 150cc, both types of lower powered two-wheelers (less than 50cc and 51-150cc) had higher hazard ratios in three kinds of duration models. The hazard ratios indicated that the lower the engine size the higher the hazard for a motorcycle being ended holding or being disposed of. It also showed that the disposal hazard was higher than the transfer hazard for motorcycles with a

lower engine capacity in terms of holding duration. A higher replacement cost might be the explanation that motorcycles greater than 150cc would have a lower chance to be ended its holding, and even if the ownership termination occurred, these higher engine sized motorcycles would have a greater likelihood of being transferred instead of being disposed of.

In addition, as a dependent variable, the age of a used motorcycle owned at the beginning associated positively with the hazard rate contributed by lower-powered motorcycles. The results indicated that holders appeared to buy more aged motorcycles with larger engine size than buy a more aged motorcycles with lower engine size. This can be connected with the above explanation about the replacement cost. Therefore, older motorcycles with larger engine size appear to have a relatively higher circulation chance in the second-hand motorcycle market.

2. Motorcycle usage attributes

(1) Holder's sex

Different with the result that females had a higher probability of replacing their vehicle sooner (De Jong, 1996), holder's sex did not show any association both in the models for holding duration and disposal age in this study. On the other hand, male holders had a higher proportion (32.5%) to own a second-hand motorcycle than females (25.0%). Of these used motorcycles, male holders also had a higher willingness to buy a used motorcycle with more age than did females.

(2) Holder's age

Holder's age had a negative association with the hazard among the three types of duration models. Older holders had not only a longer ownership duration but also a higher scrappage age for their motorcycles. They also bought a more aged second-hand motorcycle with higher willingness.

De Jong (1996) pointed out that older people tended to possess cars for a longer period due to the formation of stronger habits. In addition, this study raises another possible reason that older people extend their motorcycle holding duration and scrappage age and buy more aged second-hand motorcycles because they ride less frequently, have a shorter mileage, and conduct a more check to keep their motorcycles in a relatively good condition (Chang and Yeh, 2007).

(3) Running mileage

Riding distance per week associated positively with the hazard rate of the holding

duration especially ended by a transfer, but revealed no association with the disposal age. This appears consistent with the past research that higher vehicle miles traveled (De Jong, 1996; Yamamoto and Kitamura, 2000) and vehicles with higher odometer readings (Gilbert, 1992) had a higher hazard for terminating vehicle ownership. A possible explanation might be that higher running mileage was likely to increase attrition and risk of motorcycle damage. This could be supported by the statistic that the correlation coefficient (0.29) between running mileage and maintenance cost showed a mildly correlated relationship.

In addition, the hazard of the age of second-hand motorcycle purchased was also positively correlated with the running mileage. People needing a longer mileage ride demonstrated their unwillingness to buy a used motorcycle with a higher age possibly for a safe or comfortable reason.

(4) Maintenance costs

Maintenance costs associated positively with the hazard rate among the three different duration models. This means that owners spending higher maintenance costs may reduce their motorcycle ownership duration and scrappage age due to heavy attrition for their motorcycles. In addition, a currently higher maintenance cost associated with a lower age of used motorcycles being initially held. Similar to the running mileage, owners spending higher maintenance costs might represent the motorcycles being heavily used and being the principal traffic means, thus reducing the propensity of buying a used motorcycle with more age at their initial holding.

(5) Motorcycle size of household

Compared with three or more motorcycles in a household, the only motorcycle and two motorcycles respectively had a higher hazard ratio for all of the duration models, except for the holding duration ended by transfers. The sampled motorcycle in a two-motorcycle household appears to have even lower holding duration and scrappage age than those in a one-motorcycle household. This contradicts with the previous studies that the household fleet size was positively correlated with the hazard for ending the holding duration of the observed automobile (De Jong, 1996; Yamamoto and Kitamura, 2000). The reason why the number of cars increased in a household, the shorter the holding duration of the observed car may result from the income effect that more cars in the household indicated higher consumption ability, and thus lead to a sooner replacement on the observed vehicle.

On the contrary, our result indicated that if holders owned the only motorcycle or

two motorcycles in the households, they would be more likely to terminate the motorcycle holdings by scrapping as compared with those with three motorcycles or more in their households. This appears to demonstrate the substitution effect among motorcycles in a household. Since no or fewer motorcycles in a household can be alternatively used, the sampled motorcycle would reduce both its holding duration and life span by scrapping. Therefore, conspicuous consumption might be appropriate to explain the car being replaced sooner if additional cars are owned in the household, but the motorcycle would be scrapped later if three motorcycles or more are owned in the household due to the substitution effect.

In addition, being the only motorcycle or two motorcycles in a household reduced their chance of being purchased second-hand with more age. This also might be the case that less motorcycles in a household reduced the possibility for alternative use, and thereby good vehicle condition is required more highly.

(6) Car size of household

Motorcycle owners in a no-car household and only one-car household both had a higher hazard ratio for scrapping their motorcycles as compared with owners in a households with two cars or more, but no association with the sampled being transferred. This may result from the existence of the substitute use relationship between car and motorcycle in a household (Jou et al., 2004).

Also, motorcycle owners in a no-car household appeared not to buy a more aged second-hand motorcycle. This might be the fact that the only motorcycle in a no-car household reduces the possibility for substitution with additional vehicle, and thus the owner requires good vehicle condition for his/her only motorcycle more highly.

(7) Monthly income

Owners having lower monthly income decreased the hazard of disposing of their motorcycles, but no association with ending ownership by transferring them. This is consistent with the past studies on cars (Gilbert, 1992; Yamamoto and Kitamura, 2000). In addition, owners of lower income increased the initial holding age for the used motorcycles. A longer time for motorcycle holding, higher scrappage age, and a more aged second-hand motorcycle purchased appear to demonstrate that low-income owners have a relatively conservative consumption behavior.

Table 18　Associations with Hazard Ratio of Estimated Cox Regression Results

Independent variables	Hazard ratio of holding duration			Hazard ratio of disposal age			Hazard ratio of age of used motorcycle	
	Model 1 (pooled)	Model 2 (disposal)	Model 3 (transfer)	Model 4	Model 5	Model 6	Model 7	Model 8
Used motorcycle	+++	+++	+++	+++	+++	+++	N.A.	N.A.
Age of motorcycle purchased	+++	+++	+	- - -	- - -	- - -	N.A.	N.A.
CC(1)	+++	+++	+++	+++	+++	+++	+++	+++
CC(2)	+++	+++	+++	+++	+++	+++	+++	+++
Sex	×	×	×	×	×	×	- - -	- - -
Holder's age	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Running mileage	+++	×	+++	×	×	×	+++	+++
Maintenance costs	+++	+	+++	++	++	++	++	++
Household motorcycle size(1)	×	+	×	+	×	++	+++	+++
Household motorcycle size(2)	+	+++	×	+++	+++	+++	+++	+++
Household car size(1)	++	++	×	++	++	+++	+++	+
Household car size(2)	×	++	×	+	+	+	×	×
Monthly income	×	- -	×	- -	-	- -	×	- -
Greater Taipei	-	×	×	×	- - -	×	×	++
Unemployment rate	- - -	- - -	×	- - -	N.A.	N.A.	+++	+++
Motorcycle density	- - -	×	- - -	×	N.A.	N.A.	×	×
Passenger car density	- - -	×	- - -	×	N.A.	N.A.	×	×
Consumption propensity	+++	+++	++	+++	N.A.	N.A.	×	+
Engel's coefficient	×	- -	×	×	N.A.	N.A.	×	×
Inspection rate	N.A.	N.A.	N.A.	N.A.	×	N.A.	+++	N.A.
Ineligibility rate	N.A.	N.A.	N.A.	N.A.	- - -	N.A.	- -	N.A.
Inspection station density	N.A.	N.A.	N.A.	N.A.	- -	N.A.	- - -	N.A.
Inspection performance cluster	N.A.	N.A.	N.A.	N.A.	N.A.	+++	N.A.	×

Note: 1. "+" and "-" represent positive and negative association respectively; "×"represents no association; "N.A." means "not applicable".
　　　2. One, two, and three of "+" or "-" represent the estimated parameter statistical significance at α=0.1, 0.05, and 0.01 respectively.

(8) Greater Taipei

Being the only region with mass rapid transit system in Taiwan, motorcycles registered in Greater Taipei had a pooled longer ownership time and a higher scrappage age, but they did not show any differences in holding duration with motorcycles registered in other districts from the point of any single event (disposal or transfer termination). The negative hazard association might be explained by part of the substitution effect between the use of motorcycles and the availability of alternative modes in Greater Taipei. In addition, motorcycles registered in Greater Taipei associated with the age of used motorcycle purchased in a positive direction on the hazard, meaning that owners in Greater Taipei appear reluctant to own a used motorcycle with old age.

3. Aggregate socioeconomic attributes

(1) Unemployment rate

Consistent with the study on automobile holding by Gilbert (1992), a high unemployment rate of a district reduced the hazard that ended the motorcycle holding by disposals in that district, but no association between the unemployment rate and the hazard that ended the motorcycle holding by transfers. Also, a high unemployment rate increased the mean scrappage age of motorcycles in a district. The results may arise from a more conservative consumption behavior in high jobless-rate areas, and thus disposing of the motorcycles later in these areas.

However, the hazard of the ownership of old aged second-hand motorcycles raised as the unemployment rate increased in a district. This means the district's mean age of second-hand motorcycles would be shorter at the initial holding for those districts with high unemployment rate. Combined with the above holding duration and motorcycle age, a district with a higher unemployment rate on average has a propensity to buy newer second-hand motorcycles, but the overall holding duration or motorcycle lifetime would be longer. This might be that even though more conservative consumption behavior is likely to exhibit in a higher unemployment-rate district, the owners buy newer used motorcycles possibly due to motorcycles being the principal traffic mode in the district.

(2) Motorcycle density

The increase in motorcycle density in an area, on average, decreased the hazard ratio of motorcycle holding termination, but displayed no association with the hazard ratio of scrapping a motorcycle in terms of the motorcycle life span. This dose not agree with our original hypothesis. Our speculation that motorcycles were more likely to be the principle mode of transportation in higher motorcycle ownership areas, which would result in heavier usage of motorcycles and produce a shorter holding duration, appears not validate.

In contrast, the correlation coefficient between motorcycle density and Engel's coefficient among areas was 0.45, while between motorcycle density and consumption propensity, it was −0.32. It appears that a higher motorcycle density may be highly associated with lower consumption ability and a more conservative consumption propensity of a district, thus increasing the average district's holding duration for motorcycles.

(3) Passenger car density

Similar to district's motorcycle density, the increase in passenger car density in a district decreased the hazard ratio of ending motorcycle holdings. The results appear validate the speculation that passenger cars may have a partial substitution effect on motorcycles, and thus high density of passenger cars are more likely to reduce the average usage frequency of motorcycles, leading to a longer district's holding duration.

(4) Consumption propensity

Higher consumption propensity in a district raised the hazard of scrapping motorcycles in terms of both holding duration and scrappage age. In accordance with our previous hypothesis, a stronger consumption propensity in a district would increase the holders' intention to dispose of or transfer their motorcycles sooner.

In addition, this variable mildly associated with the initial holding age for the used motorcycles in a positive direction on the hazard at a district level, indicating that holders in a district with a high consumption propensity would buy newer second-hand motorcycles.

(5) Engel's coefficient

Contrary to high consumption propensity, high Engel's coefficient of a district represents a lower consumption ability to spend on durable goods. This variable in the holding duration model, as expected, was mildly associated with the motorcycle ownership ended by disposals in a negative direction.
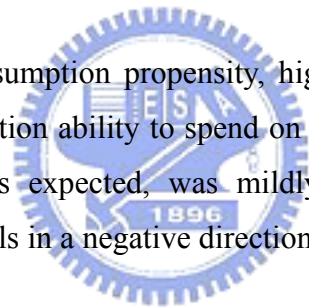
4. Aggregate inspection performance attributes

Only duration models for motorcycle scrappage age and age of second-hand motorcycles at initial purchase were used to examine the associations with these inspection performance variables.

(1) Inspection rate

Districts with higher inspection rate did not show any association with the hazard for disposing of motorcycles, but positively associated with age of second-hand motorcycles purchased. The association means higher inspection rate of a district appears to have second-hand motorcycles with newer age at initial holding in that district. Whether the purchase of a newer second-hand motorcycle increase the holder's willingness to attend the emissions inspection need further examinations.

(2) Ineligibility rate

As expected, average district ineligibility rate did show negative association with both the hazard for disposing of motorcycles and age of second-hand motorcycles

purchased. This appears to indicate that better performance due to lower ineligibility rate of a district associated with a shorter scrappage age of motorcycles and also the intention for buying newer second-hand motorcycles in that district.

(3) Inspection station density

The inspection station density showed negative association with both the hazard for disposing of motorcycles and age of second-hand motorcycles at initial holding. On a regional perspective, a higher service density increasing both the disposal age and the purchase age of second-hand motorcycles might be that motorcycles in these districts have relatively high accessibility to the maintenance channel and also these stations offered a higher possibility in circulation of the second-hand motorcycles with old age. These factors are likely to extend the overall life span of motorcycles and age of the second-hand motorcycles. However, the speculations need more detailed examinations.

(4) Inspection performance cluster

As expected, districts in the cluster with good inspection performance associated positively with the hazard for disposing of motorcycles, and thus shortening the motorcycle scrappage age in these districts. However, there was no association between the cluster variable and the purchase age of the second-hand motorcycles.

6.2.2 Association of Odds Ratio

The association between individual independent variables and two types of logistic regression models was to explore the relative odds for the two competing risks in terminating motorcycle ownership and for a used or new motorcycle purchased at the initial holding. Each variable under different attribute types is presented one-at-a-time while controlling for other variables (Table 19).

1. Vehicle attributes

For the two different natures of competing events, whether a used or new motorcycle at the initial holding did not raise any likelihood in experiencing a disposal event more than a transfer event. However, more age of a motorcycle purchased increased the odds in scrapping the motorcycle than in transferring it. A 5-years-old used motorcycle raised the odds ratio in disposing of a motorcycle by 2.61 times a brand new motorcycle at the initial holding (calculated from model 15 in Table 16). Lower engine size of less than 150 cc showed a higher likelihood of being scrapped

than being transferred as compared motorcycles larger than 150 cc. Also, holders intended to buy a second-hand motorcycle larger than 150 cc more likely than those lower-powered motorcycles less than 150 cc. As previously discussed, larger engine size had both longer holding duration and disposal age. Combined with larger engine sized motorcycles with more age being purchased at the second-hand market, this may represent these larger motorcycles reveal a characteristic for durability and high trade-in values.

2. Motorcycle usage attributes

The two competing risks of ending a motorcycle holding did not show any difference between sexes. However, males revealed a higher likelihood of buying a used motorcycle than females. The reason might be that females have a weaker recognition about vehicle structure, maintenance, and checks, and thus they incline to use a motorcycle with a presumably better condition and to have a lower tendency to hold a second-hand motorcycle.

Older holders tended to end their motorcycles by disposals than by transfers. They also had a lower tendency to buy a used motorcycle. As previously mentioned, older people held and disposed of their motorcycles with longer years. This appears to support the idea that older people are likely to form a stronger habit on their motorcycles.

Higher riding distance per week lowered the odds of disposing of a motorcycle as compared with the odds of transferring it. This can also be validated by the duration models that motorcycles being used heavily had more hazard by transfers than by disposals. The results might indicate that a motorcycle being heavily used is still in good condition, thus the owner ends the holding more likely by selling it than by scrapping it. A heavy running mileage needed also reflected less chance of owning a second-hand motorcycle by the holder.

Higher maintenance costs did not show any association with the occurrence odds between the two competing events for terminating holding. However, higher costs in maintenance revealed a higher likelihood of a used motorcycle being held. This might reflect the decayed vehicle condition of a used motorcycle.

Compared with three or more motorcycles, an owner having two motorcycles or only one motorcycle in the household had a higher probability to dispose of the observed motorcycle than to transfer it, possibly due to the relatively heavy usage of the

sampled motorcycle in a household with lesser motorcycles. In addition, the only motorcycle in a household revealed less chance to be a second-hand vehicle. This is perhaps being the only motorcycle and without other substitutions in the household, owners tend to buy a brand new motorcycle to keep it in more reliable condition.

Household car size did not show association with the odds between the two competing events for terminating holding. A motorcycle owner having no cars in his/her household showed a less propensity to buy a used motorcycle, possibly due to lower substitute chance by cars.

Personal monthly income did not influence the odds in scrapping or transferring a motorcycle and as well the odds in holding a second-hand or new motorcycle.

Motorcycles registered in Greater Taipei showed no difference in the likelihood of transferring or disposing of a motorcycle. In addition, owners in Greater Taipei had a less chance to possess a used motorcycle. Combined with the previous results in the duration models, in Greater Taipei motorcycles are purchased newer, held and survived longer.

3. Aggregate socioeconomic attributes

A high unemployment rate of a district reduced the motorcycle scrappage likelihood for the district's owners, and also increased their odds in buying a used motorcycle. This might reflect lower consumption ability in the high unemployment districts.

Motorcycle density in an area had no association with whether a motorcycle was disposed of or transferred, and whether a used or new motorcycle was purchased, but passenger car density in a district raised the odds for purchasing used motorcycles in that district, possibly due to a partial substitution effect between the two types of traffic modes.

However, contradicting with the intuition, higher consumption propensity in a district raised the likelihood of a used motorcycle being purchased. This might be explained by the case that motorcycles in a district with high consumption propensity are more likely to be a subsidiary mode as compared with a passenger car, and less frequent use increase the owners' intention to buy a used motorcycle in that district. This speculation still needs more careful examinations. Engel's coefficient, on the other hand, did not show any associations in both of the two types of logistic regression models.

Table 19   Associations with Odds Ratio of Estimated Logistic Regression Results

Independent variables	Disposal/transfer Competing risks	Used/new motorcycle ownership	
	Model 15	Model 16	Model 17
Used motorcycle	×	N.A.	N.A.
Age of motorcycle holding	+++	N.A.	N.A.
CC(1)	+++	-	-
CC(2)	+++	- -	- -
Sex	×	+++	+++
Holder's age	+++	- - -	- - -
Running mileage	- -	- - -	- - -
Maintenance costs	×	+++	+++
Household motorcycle size(1)	+++	- - -	- - -
Household motorcycle size(2)	+++	×	×
Household car size(1)	×	- - -	- - -
Household car size(2)	×	×	×
Monthly income	×	×	×
Greater Taipei	×	- - -	- - -
Unemployment rate	- - -	+	×
Motorcycle density	×	×	×
Passenger car density	×	+++	+++
Consumption propensity	×	+++	+++
Engel's coefficient	×	×	×
Inspection rate	N.A.	×	N.A.
Ineligibility rate	N.A.	×	N.A.
Inspection station density	N.A.	-	N.A.
Inspection performance cluster	N.A.	N.A.	- - -

Note: 1. "+" and "-" represent positive and negative association respectively; "×" represents no association; "N.A." means "not applicable".
    2. One, two, and three of "+" or "-" represent the estimated parameter statistical significance at α=0.1, 0.05, and 0.01 respectively.

4. Aggregate inspection performance attributes

Inspection performance attributes were only used in the model for comparing the odds in a used and new motorcycle purchased. Two of the three continuous variables: inspection rate and ineligibility rate of a district showed no association with the odds in whether a used or new motorcycle was purchased, but a district with higher inspection station density reduced the odds of holding used motorcycles in the district. However, the cluster of better inspection performance districts decreased the likelihood of a second-hand motorcycle being purchased. This might reflect people living in districts with better inspection performance on emissions are more likely to purchase a new

motorcycle for their initial holding and dispose of their motorcycles sooner (from the previous duration model).

6.3 Implications

We summarize some of the policy implications connected with old motorcycles, emissions inspection, and registration system as follows:

1. The supervision of active second-hand motorcycles should be enhanced

Regions with a lower inspection and higher ineligibility rate correlated with an older age of second-hand motorcycles purchased. Motorcycles in the poorer inspection performance districts had 7% of emissions ineligibility rate higher than the better performance districts and this reduced the hazard by 13.1% for measuring age of second-hand motorcycles purchased, which led to older used motorcycles transferred in these districts. Around 30% of the samples were used motorcycles and the mean age of being purchased was 5.69 years. In addition, around 57% of the sampled motorcycles undergoing an event was ended by transfer but not by scrappage. Even though these second-hand motorcycles appear not show a higher scrappage age as compared with motorcycles being purchased new, their quality depending on the use of the previous holders may not be guaranteed. Therefore, a better supervision of this vast proportion of second-hand motorcycles should be made. Currently, a new regulation in 2006 has been enacted that the transfer of a vehicle aged over 5 years is requested to take a mandatory safety check. Whether this regulation has any effect on the safety improvements, scrappage rate, and even purchased or scrappage age of second-hand motorcycles needs further examinations.

2. The emissions inspection rate for motorcycles should be raised

Taiwan's overall mean of motorcycle inspection rate was around 47.8%, and there were no differences between two clusters of performance-based districts during the period of 1999-2003. This lower-than-half rate revealed that a vast amount of motorcycles were not under emissions supervision. It may be speculated that motorcycles not attending the annual inspection have higher pollutant emissions, and as a result the real ineligibility rate, CO and HC emissions values per motorcycle are

underestimated.

Since the annual motorcycle inspection is a mandatory regulation, enforcement such as roadside pullover testing and fines for motorcycles without inspection documentation should be substantially enhanced. The license plate of a car can be revoked if it violates the safety check regulations (i.e. including emissions inspection). However, this is at present not applicable for motorcycles that violate the emissions inspection regulation. A more severe intervention, such as the penalty of revocation of the motorcycle license should be considered if an increase in inspection rates by itself does not accomplish the required results.

3. Emphasis should be placed on improving the lower inspection performance districts

The districts with a lower performance of motorcycle inspection had a substantially higher ineligibility rate, CO emissions, and HC emissions on average than those of the higher performance districts. The 7% higher emissions ineligibility rate in the lower performance districts reduced the district's scrappage hazard by 42.5% on average and also the lower performance clustering districts reduced the district's scrappage hazard by 27.0%.

Geographically, most lower performance districts were located in the southern part of Taiwan. The lower inspection performance districts also had a longer motorcycle mean age, which likely increased the emissions levels for motorcycles in use within the districts. Therefore, the question of how to improve the weaker functioning inspection programs in the southern districts of Taiwan should be addressed with some sense of urgency.

4. A mechanism to eliminate old motorcycles should be established

The mean and median scrappage age of motorcycles equaled to 13.3 and 12.99 years respectively. Also, the 8.1 years of active mean age appears to be higher compared with other countries taking into account the vast amount. The use of such an extremely high proportion of very old motorcycles has produced not only excessive emissions, but they also consume more energy and pose serious safety problems. An improved regional motorcycle inspection mechanism and the lowering of the motorcycle mean age, can result in a lower ineligibility rate and the acceleration of the disposal hazards of motorcycles. In addition to the needed improvements in the motorcycle inspection program, other interventions such as accumulative taxation,

mandatory periodic vehicle examination, enhanced VAMR program, and alternative-powered motorcycles should be considered to reduce the usage of gasoline-powered old motorcycles.

5. The correctness of the records in the VRS should be improved

The split-population duration models suggest that about 21% and 47% of the sampled motorcycles in terms of holding duration and scrappage age respectively fail to register their status of terminating ownership. This may arise from the fact that the Vehicle Registration Agency does not enforce periodic vehicle examinations for motorcycles under 250cc in Taiwan. The agency has no appropriate mechanism, such as penalties or vehicle plate revocation, that would allow for an update in the accuracy of motorcycle registrations. In addition, although an annual emission check on all types of motorcycles was implemented by the Environmental Protection Agency, the emissions inspection rate is low and examination system is not linked to the vehicle registration system. Therefore, the rather slack management of motorcycle registrations has created a bias in official records. These inaccuracies in motorcycle registration could result in errors when establishing strategies for transportation planning, management, environmental protection, and even international comparisons. It is suggested that the correctness of the VRS records be improved.

6.4 Research Limitations

The registration records determined the duration variables: holding duration, disposal age, and age of motorcycle purchased. We employed the MOTC's sampled motorcycles to retrieve their vehicle and usage attributes, and linked these samples with their officially reported aggregate attributes concerning socioeconomic and motorcycle emissions inspection characteristics by districts. The associations between duration variables, binary outcomes for competing risks and a second-hand motorcycle or not, and their determinants could be identified in this study. However, some limitations about research design and modeling issues should be noted in the following discussion.

6.4.1 Research Design Issues

1. The gap between the VRS records and real usage information

Duration variables were identified by the occurrence of events such as disposals or transfers in the registration system. However, based on the registration records, the estimated of holding duration and disposal age of a motorcycle may have a gap with the real "usage" status.

Samples in the MOTC survey on motorcycle usage indicated a proportion of the sampled motorcycles had been discarded or suspended for use. Around 18% of the samples reported without being used (MOTC, 2000). Of these motorcycles being discarded or use-suspended, 21.5% had not been used temporarily for over 3 months, 25.2% was stolen, and 53.3% was disposed of. However, only 14.2% of the motorcycles being stolen and 17.4% being disposed of had finished the change of the registration status in the VRS. Therefore, if we omit the proportion of motorcycles without being used temporarily, the most conservative estimation for the proportion of motorcycles that had been stolen or disposed of, but not finished their registration status was around 11.8% (=18%*(25.2%*85.8%+53.3%*82.6%)) at the end of 1999. Of the sampled motorcycles, this proportion of not-in-use motorcycles may increase over time due to the slack management registration system.

To correct this problem, a split-population was employed. The split-population duration model in examining the holding duration indicated that around 21% of the registration records had been prolonged censoring, while in examining the scrappage age 47% were prolonged censoring at the end of the observation, on February, 2004. However, the split-population parameter in estimating the prolonged censoring or never undergoing events is also based on the information of the event data as well. Two kinds of events in the registration system may also have a difference with the real termination of a motorcycle use. Some disposal or transfer events are likely to be delayed in reporting to the VRS due to the owners have no time, feel no urgency, or any other excuses and the like. This may be caused by the reason that only a not-so-expensive biyearly registration fee has to be paid for the motorcycles less than 150 cc, and if the real time of motorcycle disposal or transfer is far away from the fee due, they may delay the time to report to the VRS.

However, the errors from the registration records do not mean these records are useless. Statistics from the official registration data is vital for international comparisons. How to capture the characteristic of the registration data and improve the data quality through a suitable research design are important issues for the future

research. Using a split-population duration model is the first trial. It is suggested that a second wave survey be used further by following up the usage information of the sampled motorcycles to reduce the errors from the registration information. If this can be reached by excluding from the Protection Law for Computer Dealing with Personal Information, the real "usage" durations for holding a motorcycle can be collected and the difference between registration and usage years can also be compared.

2. The limitation of the observation period

A follow-up observation of the event (either a transfer or disposal record) from the VRS was undertaken during more than four-year observation period (from December 15, 1999 to February 15, 2004). However, The event proportion in the overall samples might be a bit low and reduce the statistical precision.

Only 30% of the samples in terms of holding duration and 11.5% in terms of scrappage age experienced the events during the observation spell. The censoring rate reduced from 70% to 62% in the analysis of holding duration and from 88.5% to 78.3% in the analysis of scrappage age after correcting by a split-population method. However, even though the samples have been split, the median survival time for holding duration and scrappage age were inflated (around 5 years and 3 years respectively) as compared with the median estimated by the samples simply experiencing events.

The four years of observation was less than half of the mean holding duration and one-thirds of the mean disposal age. To increase the precision of the estimation, we suggest the observation spell be extended to reduce the censoring rate.

3. Collection of dynamic attributes

Only one wave of survey in this study lost the chance to follow-up the observation of dynamic change of the sample attributes. As mentioned earlier, another wave of survey can mitigate the gap between the real usage information and the registration records regarding the duration variables. The transaction status such as replacement with a new motorcycle, replacement with a used motorcycles, and disposal without replacement cannot be distinguished simply by the VRS records. The transaction information is crucial for predicting the change of household vehicle ownership in a dynamic model.

In addition, some independent variables may change over time such as personal income, running mileage, and vehicle maintenance costs, etc. The dynamic attributes, if

available, can be accommodated into a duration model using as time-dependent variables. However, limited by the simply one wave survey, all the independent variables were assumed fixed across time. Even if the assumption is reasonable to some extent because the around 4-years observation period is not that long, this hypothesis still raises errors from some of the attributes changing dramatically within the period. A second wave investigation raised above can mitigate, even cannot entirely remove, this problem by collecting the change of attributes in another time panel.

4. Application of households' perspective

The joint decision on car/motorcycle ownership and their use has been established by recent studies (Jou and Chen, 2003; Jou, Liu, and Wang, 2004; Jou, Chen, and Weng, 2004). The possibility of the substitute relationship between car and motorcycle in a household reveals that the observed motorcycle holding duration and scrappage age may be affected by whether the ownership of another car and the car usage in a household.

The additional car ownership in a household shows no significant effect on the investigated duration of the sampled motorcycles at present. However, this may result from the fact that the MOTC's questionnaire was not designed at a household level but more at an individual level. A complete household perspective such as household fleet composition and their usage, household size, employed persons, and life stage of a household, etc. is suggested conducting in future's data collection.

6.4.2 Future Modeling Issues

1. Relaxation of the conditional independence hypothesis among competing risks

The conditional independence hypothesis about the two competing evens assumes that the duration ended by transfers has no association with the duration ended by disposals, and vice versa. This assumption possesses an easier statistical property.

However, the trade-in value being left appears to induce an owner to transfer his/her motorcycle as much as possible, and hence the independence assumption may be violated. According to Hensher and Mannering (1994), accounting for interdependence among competing risks is not easy but has been raised by a few studies. How to relax this conditional independence hypothesis may be a good issue to develop for the future work.

2. Heterogeneity and time-varying covariates

We have used the split-population duration model to deal with a special heterogeneity that part of the motorcycles may actually have been terminated but not been registered in the VRS. In addition to this kind of heterogeneity, the unobserved heterogeneity, due to the omission of important factors in the $\exp(X \cdot \beta)$ function, can result in a major specification error that may lead to wrong inferences on the shape of the hazard function and the parameter estimates. This can be corrected by either using a heterogeneity term (i.e. gamma distribution is commonly assumed) or non-parametric method (i.e. mass point non-parametric approach) (Hensher and Mannering, 1994; Chen and Lin, 2006). Also, time-varying covariates have been studied in several duration models (De Jong, 1996; Chen and Niemeier, 2005; Chen and Lin, 2006). There needs more examinations about the time-varying covariates, if available, for the future studies.