CHAPTER 5 RESULTS

5.1 Basic Statistics

5.1.1 Descriptive Statistics for Independent Variables

The measurement scale for independent variables was classified into categorical and continuous variables. The descriptive statistics for these two kinds of variables are given in Table 4.

The categorical variables, including “used motorcycle”, “engine size”, “sex”, “household motorcycle size”, “monthly income”, “Greater Taipei”, and “inspection performance cluster” were listed as percentages. The holder possessing a used motorcycle made up 29.5% of the MOTC’s sampled motorcycles. An engine size of 50 cc or under comprised 36.7% of all samples, while 51-150 cc made up 60.8% and those over 150 cc only 2.5%. Male owners made up 59.3% of the samples. The sampled motorcycles which were the only motorcycle in a household accounted for 21.7%, two motorcycle in a household for 35.4%, and three or more motorcycles for 42.9%. On the other hand, households had no cars, one car, and two cars or more accounted for 31.6%, 46.9%, and 21.5% respectively. The sampled holders with personal monthly income less than 30,000 NT dollars made up 60.7%. Samples in Greater Taipei made up 23.3% of all the samples. Inspection clustering into better performance, however, accounted for 60.8% of all.

The means and standard deviations of the continuous variables were also provided. As exhibited in Table 4, the overall mean “age of motorcycle purchase” was 1.71 years. However, of the used motorcycles only, the mean age was 5.69 years. “Holder’s age” had a mean of around 43 years. Their mean “running mileage” was about 59 km per week and the mean “annual maintenance costs” being paid was around 1,900 NT dollars. For the district’s socioeconomic variables part, the mean values were 4.1% for unemployment rate, 558 motorcycles and 220 passenger cars being owned per thousand persons, 75.4% for consumption propensity, 23.2% for Engel’s coefficient. In addition, the district’s emissions related variables showed a mean of 47.8% for inspection rate, 18.9% for ineligibility rate, and 1.3 stations per 10,000 registered motorcycles averaged over the period 1999-2003.

Table 4 Descriptive Statistics for Independent Variables

Independent variables	Categorical variables Percentage	Continuous variables Mean (Standard deviation)
Vehicle attributes:		
Used motorcycle (%)	29.5%	—
Age of motorcycle purchased (years)	—	Overall: 1.71 (3.55)/ Used only: 5.69 (4.33)
CC(1)(equal or less than 50cc)	36.7%	—
CC(2)(51 to less than 150cc)	60.8%	—
CC(3)(150cc or more)	2.5%	—
Motorcycle usage attributes:		
Sex (male)	59.3%	
Holder's age (years)	—	42.66 (12.96)
Running mileage (km/week)	—	58.88 (65.43)
Maintenance costs (NT dollars)	—	1893.11 (1545.84)
Household motorcycle size(1)(one)	21.7%	—
Household motorcycle size(2)(two)	35.4%	—
Household motorcycle size(3)(three or more)	42.9%	—
Household car size(1)(none)	31.6%	—
Household car size(2)(one)	46.9%	—
Household car size(3)(two or more)	21.5%	—
Monthly income (%) (less than 30,000 dollars)	60.7%	—
Greater Taipei (%)	23.3%	—
Aggregate attributes:		
Unemployment rate (%)	—	4.10 (0.51)
Motorcycle density (vehicles/per thousand persons)	—	558.09 (77.53)
Passenger car density (vehicles/per thousand persons)	—	220.25 (30.52)
Consumption propensity (%)	—	75.42 (3.82)
Engel's coefficient (%)	—	23.21 (2.34)
Inspection rate (%)	—	47.79 (4.34)
Ineligibility rate (%)	—	18.90 (4.54)
Inspection station density (stations per 10,000 motorcycles)	—	1.30 (0.37)
Inspection performance cluster (%) (samples in better performance districts)	60.8%	—

5.1.2 Differentiation of Regional Inspection Performance

A K-means cluster analysis based on five of the inspection-related variables just mentioned was applied to identify regional differences in policy implementation. The five inspection variables are defined as follows. The average inspection rate is measured as the percentage of vehicles participating in the annual mandatory emissions inspection. The inspection station density is calculated as the number of approved inspection stations per 10,000 registered motorcycles. The average ineligibility rate is measured as the percentage of motorcycles failing to pass applicable standards for either CO or HC emissions. The average level of CO (%) and HC (ppm) emissions are measured for motorcycles inspected. Each variable is reduced to the average of all five annual values taken over the period 1999-2003, and is measured separately in each administrative district.

Overall means reveal that fewer than half (47.8%) of registered motorcycles were inspected, 18.9% of inspected motorcycles were found ineligible, and only 1.30 inspection stations were available per 10 thousand motorcycles. The average levels of CO and HC emission were 2.46% and 2,741 ppm, respectively (see Table 5). Only two regional clusters were defined, since additional groupings were found to have no further differentiation effect (i.e., statistical significance) for the Cox regression model. Table 5 also reports the mean values of inspection-related predictors for the two clusters. Districts in cluster 1 had a slightly higher inspection rate and station density, a lower ineligibility rate, and lower CO and HC emission levels than those in cluster 2. Motorcycles in cluster 2 on average were 6.97% more likely to be found ineligibile, had CO values 0.42% higher, and produced 893 ppm more HC than those in cluster 1.

The one-way MANOVA was also applied to test the mean differences of these five variables between the two cluster populations. The Wilks' Lambda (Λ) value, equal to 0.234, was transformed to a Rao statistic (=11.12) following an $F_{5,17}$ distribution. This allows rejection of the null hypothesis that all five means were equal at $\alpha = 0.05$. In addition, individual ANOVA results between the two populations reveal that the mean differences in ineligibility rate ($F_{1,21} = 32.27$), CO emissions ($F_{1,21} = 33.08$) and HC emissions ($F_{1,21} = 61.44$) are statistically different from zero. The zero difference hypothesis could not be rejected, however, for the inspection rate ($F_{1,21} = 0.02$) and inspection station density ($F_{1,21} = 1.59$).

Geographically, most of the districts with better implementation of the I/M program (i.e., the districts in cluster 1) are located in the northern region of Taiwan or off-shore; the southern region of Taiwan obviously performed more poorly. The specific administrative districts belonging to each cluster are listed in Table 6.

Table 5 Regional Cluster Centers of Emission-related Variables

Variable	Overall (23 districts)	Cluster 1 (13 districts)	Cluster 2 (10 districts)
Inspection Rate (%)	47.79 (4.34)	47.89 (3.60)	47.65 (5.35)
Ineligibility Rate (%)	18.90 (4.54)	15.87 (3.26)	22.84 (2.38)
Inspection Station Density	1.30 (0.37)	1.39 (0.40)	1.19 (0.33)
(stations per 10,000 motorcycles)			
CO Emissions (%)	2.46 (0.27)	2.27 (0.20)	2.69 (0.13)
HC Emissions (ppm)	2741 (525)	2353 (290)	3246 (243)

Note: Numbers in parentheses represent one standard deviation.

Table 6 Regional Cluster Membership by District

Administrative district	Cluster 1	Cluster 2
Yilan County	N	
Keelung City	N	
Taipei City	N	
Taipei County	N	
Taoyuan County	N	
Hsinchu City	N	
Hsinchu County	N	
Miaoli County	N	
Taichung City		C
Taichung County	C	
Changhua County	C	
Nantou County	C	
Yunlin County		C
Chiayi City		S
Tainan City		S
Chiayi County		S
Tainan County		S
Kaohsiung City		S
Kaohsiung County		S
Pingtung County		S
Taitung County	E	
Hualien County		E
Penghu County	OS	

Note: “N”, “C”, “S”, and “E” stand for North, Central, South and East Taiwan; “OS” stands for offshore Taiwan.

5.1.3 Descriptive Statistics for Duration Variables

Descriptive statistics of median, mean, standard deviation for the two types of duration variables are shown in Table 7.

1. Holding duration

In terms of motorcycle ownership duration at the end of the observation, two types of status were identified: censored and events by either disposal or transfer. A disposed motorcycle in the VRS means that a motorcycle not only has been terminated the registration by its holder, but also can no longer be used on the roads. Therefore, a disposal event usually represented an obsolete motorcycle that had little residual value; in contrast, this was not the case for a motorcycle transferred to a new holder. A transferred motorcycle, in general, still had residual value and was thus transferable to the next holder.

Censored data made up approximately 71% (7,644/10,778) of all observations during the observation period, with the median and mean values for censored durations being greater than 8.79 years and 10.39 years respectively. The duration for terminating motorcycle ownership revealed different results for disposals and transfers. The median (10.92 years) and mean (11.04 years) duration for disposals were both obviously longer than the median (5.89 years) and mean (6.98 years) of those motorcycles transferred. In addition, since the coefficient of variation (i.e. the standard deviation divided by the mean) for the transfer events (0.74) was higher than the disposal events (0.48), the transfers appeared to have a wider variation in holding duration. To further combine these two different events into one pooled group, the pooled events were compromised to become 7.52 and 8.75 years for the median and mean values respectively.

2. Motorcycle age

As for motorcycle age at the end of the observation, either censored or events (only disposal) can be identified. Event data comprised around 13% (1,362/10,777) of all observations, with the censored median and mean durations being greater than 9.88 years and 11.38 years respectively. The motorcycle scrappage median and mean age were 12.99 years and 13.30 years respectively.

If we further calculate the motorcycle age by different clusters of emissions inspection performance (see Table 8), all motorcycles from cluster 1 districts, which performed better inspections, had a shorter mean age. The mean age difference for scrapped motorcycles between the two district clusters was 0.41 years, while the mean age difference for motorcycles still in service was 0.72 years. Individual ANOVA tests on these results reveal that the difference in censored motorcycles ($F_{1, 9413} = 35.25$) is statistically different from zero, at α=0.05. The difference in retired motorcycles ($F_{1, 1360} = 3.09$) was also mildly significant, at α=0.1.

It may be noticed that the average duration for censored observations exhibited a longer holding duration, compared to the pooled events for motorcycle holding termination. If all the observations were randomly distributed, the central statistics for the censored data should be shorter than the events, because of the limited observation spell. That is, as a rule, the censored data that had not experienced termination simply because the observation time was not long enough; i.e. these events would eventually have come to pass, had the observation spell been prolonged. This aroused our concern towards the heterogeneity of the censored data for it inflated the holding duration estimation errors. As explained in the previous sections, some records from the VRS probably did not reflect actual motorcycle holding status, because some of the owners had not registered the correct ownership status. Therefore, it apears appropriate to employ the split-population duration model, in order to correct any possible estimation errors produced by part of incorrect registration records.

Table 7 Holding Duration and Scrappage Age of Motorcycle

Duration variable	The observation status	Number of cases	Duration descriptive statistics		
			Median	Mean	Standard deviation
Holding duration	Censored	7,644	8.79+	10.39+	5.40
	Pooled events	3,134	7.52	8.75	5.58
	(Disposal)	(1,362)	(10.92)	(11.04)	(5.26)
	(Transfer)	(1,772)	(5.89)	(6.98)	(5.16)
	Total	10,778	8.52+	9.91+	5.51
Motorcycle age	Censored	9,415	9.88+	11.38+	5.77
	Events (disposal only)	1,362	12.99	13.30	4.18
	Total	10,777	10.46+	11.63+	5.63

Note: "+" represents "greater than" in this table. (e.g. The median of the censored holding duration equal to "8.79+" years means greater than 8.79 years.)

Table 8 Motorcycle Age by Regional Inspection Performance

The end of the observation	Number of Observations	Duration descriptive statistics		
		Median	Mean	Standard Deviation
Censored	9,415	9.88+	11.38+	5.77
(Cluster 1)	(5,699)	(9.34+)	(11.10+)	(5.82)
(Cluster 2)	(3,716)	(10.83+)	(11.82+)	(5.66)
Disposed	1,362	12.99	13.30	4.18
(Cluster 1)	(855)	(13.01)	(13.15)	(4.05)
(Cluster 2)	(507)	(12.89)	(13.56)	(4.39)
Total	10,777	10.46+	11.63+	5.63
(Cluster 1)	(6,554)	(9.99+)	(11.37+)	(5.66)
(Cluster 2)	(4,223)	(11.12+)	(12.03+)	(5.55)

Note: "+" represents "greater than" in this table. (The median of the censored age of motorcycles is reported as "9.88+" years, meaning an unknown value greater than 9.88 years.)

5.2 Estimated Results for Cox Regression Model

5.2.1 Motorcycle Ownership Duration

Three types of Cox regression models based on pooled or different competing risks (events) were constructed to estimate the holding duration in association with their determinants respectively (Table 9). The pooled events for combining disposal with transfer records can illustrate the ownership duration of a motorcycle without considering the nature of events. Competing risks, however, differentiate the nature of events that a motorcycle is either disposed of or transferred by the owners.

1. Vehicle attributes

A used motorcycle had a higher hazard of being terminated holding than a new motorcycle in all the three models. For the two competing risks, a used motorcycle revealed a higher hazard ratio (4.59) of being disposed of than that of being transferred (2.01). The age of motorcycle at the time of purchase also showed a significant association for the three models. A one year age increase in a motorcycle at purchase raised the terminating hazard ratio by 5.1% (=1.051-1 in model 1), the disposal hazard ratio by 9.8%, and the transfer hazard by 2.1% respectively. The lower the engine capacity was, the higher the hazard ratio of being terminated holding experienced. The hazard of being disposed of for a motorcycle less than 50 cc was 4.46 times and for a motorcycle ranging from 51 to 150 cc was 3.51 times that of a motorcycle larger than 150 cc in the disposal model. This is obviously higher than a motorcycle being transferred (2.17 and 1.80 times) in the transfer model.

2. Usage attributes

The hazard ratios for a motorcycle being terminated holding, disposed of, and transferred were all found to be independent between sexes in the three models. Older holders tended to increase their motorcycle holding duration in three models. For each additional year in the holder's age, the hazard decreased by 3.3%, 2.3%, and 4.0% in the respective pooled, disposal, and transfer models. Increase in holder's age appeared to reduce the hazard more for a motorcycle being transferred than being disposed of. A one kilometer increase weekly raised both the hazard of terminating a motorcycle holding and transferring by 0.2%, but no association with the disposal hazard. The increase in maintenance costs by 2.72 times (i.e. equal to one unit increase by taking log) increased the hazard ratio by 13.9%, 7.2% and 19.1% in the three respective models. However, the household motorcycle size showed different influence patterns among the three models. The pooled model showed only a 9.8% increase in the hazard of holding termination for a household with two motorcycles than that of a household with over three motorcycles. A household with the only motorcycle and two motorcycles had 1.18 and 1.31 times the hazard to dispose of the motorcycle than that of over three motorcycles, while the hazard of transferring the sampled motorcycle did not show any association with household's motorcycle size. The household car size also showed different associations among the three models. Motorcycle holders having no cars in their households raised their motorcycle terminating ownership hazard by 16.5% compared with holders having two cars or more in their households. The disposal hazard also raised by 35.3% and 21.9% for the sampled motorcycle if motorcycle holders having no cars and the only car in their households compared with two cars or more households, but the transfer hazard showed no association with household car size. Owners with monthly income less than 30,000 NT dollars reduced the hazard of disposing of their motorcycles by 13.3% than those of their higher income counterpart in the disposal model. In addition, motorcycles registered in Greater Taipei had 14.4% less hazard of ending the ownership than those motorcycles registered in non Greater Taipei areas in the pooled model.

3. Aggregate attributes

An increase in unemployment rate by 1% decreased the hazard of motorcycle disposal on average by 32.8% in the disposal model and ending the motorcycle holding by 9.3% in the pooled model. Increasing motorcycle and passenger car density in an area reduced the hazard ratio of ending a motorcycle holding in the pooled and transfer models. One motorcycle and one passenger car per thousand persons increase declined the hazard ratio by 0.3% and by 0.4-0.5% respectively. However, the associated direction contributed by district motorcycle density appears apart from our expectations. In addition, a 1% increase in consumption propensity raised the hazard ratio by 2.8%, 3.8%, and 1.5% in the pooled, disposal, and transfer model respectively. Engel's coefficient, however, associated only with the disposal hazard, and a 1% increase in Engel's coefficient of a district decreased the hazard of disposing of a motorcycle by 2.6%.

Table 9 Cox Regression Results for Competing Risks on Terminating Holding

Independent variables	Model 1 (Pooled)		Model 2 (Disposal)		Model 3 (Transfer)	
	β (S.E.)	e^{β}	β (S.E.)	e^{β}	β (S.E.)	e^{β}
Used motorcycle	0.905^{a} (0.068)	2.471	1.524^{a} (0.118)	4.593	0.698^{a} (0.085)	2.009
Age of motorcycle purchased	0.050^{a} (0.009)	1.051	0.093^{a} (0.012)	1.098	0.021^{c} (0.012)	1.021
CC(1)	1.055^{a} (0.140)	2.871	1.495^{a} (0.219)	4.461	0.774^{a} (0.183)	2.167
CC(2)	0.858^{a} (0.136)	2.358	1.255^{a} (0.212)	3.508	0.586^{a} (0.179)	1.796
Sex	× ×	×	× ×	×	× ×	×
Holder's age	-0.034^{a} (0.002)	0.967	-0.024^{a} (0.003)	0.977	-0.041^{a} (0.003)	0.960
Running mileage	0.002^{a} (0.001)	1.002	× ×	×	0.002^{a} (0.001)	1.002
Maintenance costs	0.130^{a} (0.025)	1.139	0.070^{c} (0.037)	1.072	0.175^{a} (0.032)	1.191
Household motorcycle size(1)	-0.032 (0.060)	0.968	0.167^{c} (0.097)	1.182	× ×	×
Household motorcycle size(2)	0.094^{c} (0.049)	1.098	0.271^{a} (0.081)	1.312	× ×	×
Household car size(1)	0.152^{b} (0.062)	1.165	0.302^{a} (0.103)	1.353	× ×	×
Household car size(2)	0.059 (0.056)	1.060	0.198^{b} (0.091)	1.219	× ×	×
Monthly income	× ×	×	-0.143^{b} (0.072)	0.867	× ×	×
Greater Taipei	-0.155^{c} (0.092)	0.856	× ×	×	× ×	×
Unemployment rate	-0.098^{a} (0.035)	0.907	-0.397^{a} (0.056)	0.672	× ×	×
Motorcycle density	-0.003^{a} (0.0005)	0.997	× ×	×	-0.003^{a} (0.001)	0.997
Passenger car density	-0.005^{a} (0.001)	0.996	× ×	×	-0.005^{a} (0.001)	0.995
Consumption propensity	0.028^{a} (0.007)	1.028	0.037^{a} (0.009)	1.038	0.014^{b} (0.009)	1.015
Engel's coefficient	× ×	×	-0.027^{b} (0.013)	0.974	× ×	×
Number of observations	7,181		7,160		7,181	
Censored observations (rate)	5,005 (69.7%)		6,334 (88.5%)		5831 (81.2%)	
LL(β)	-16843.3		-5922.9		-10806.4	
LL(0)	-17391.4		-6258.5		-11132.9	
Degrees of freedom	16		14		10	

Notes: 1. The standard errors (S.E.) of the estimated parameters are listed in parentheses.
2. e^{β} represents the contribution to hazard rate of changing one unit independent variable at a time.
3. ^{a} denotes that the parameter is significantly different from 0 at α=0.01, ^{b} at α=0.05, and ^{c} at α=0.1.
4. "×" represents that the parameter is not significant; "N.A." means "not applicable".

5.2.2 Motorcycle Scrappage Age

Three types of Cox regression models for estimating the scrappage age of motorcycles were established according to the different aggregate socioeconomic and inspection performance variables used respectively. Parameter estimations for the three Cox regression models are shown in Table 10. The effects of each predictor on the disposal hazard are also discussed one at a time within three different categories of attributes in the three models.

1. Vehicle attributes

The disposal hazard ratio was found to be statistically significant for a motorcycle's used status at the beginning of holding in all three models. A used motorcycle at the initial time of holding had over 3 times of hazard ratio by scrapping than that of a new motorcycle (3.34, 3.24, and 3.39 respectively). Older age of a motorcycle being owned at the initial holding reduced the motorcycle scrapped hazard (0.856, 0.859, and 0.859 respectively), which means owners will extend the overall life span of motorcycles if they initially hold second-hand motorcycles with a higher vehicle age. Different engine capacities showed also a significant discrepancy in the motorcycle age of being disposed of. Engine capacity less than 50 cc and ranging from 51 to 150 cc both had a higher disposal hazard as compared with that of a motorcycle greater than 150 cc under three respective models (3.48 and 2.78 times in model 4, 3.54 and 2.92 times in model 5, and 3.31 and 2.70 times in model 6 respectively).

2. Usage attributes

Motorcycle usage variables were generally consistent with expectations towards the association to hazard ratios, except for "running mileage". The disposal hazard ratio was found to be independent with weekly distance traveled at α=0.05 in all three models. Sex factor showed no association with the hazard of scrapping motorcycles as well. As expected, older holders tended to extend their motorcycle lifetime in all models. For each additional year in the holder's age, the disposal hazard decreased by around 2.4% (=1-0.976 in model 4). The increase in maintenance costs by 2.72 times (i.e. equal to one unit increase by taking log) raised the hazard ratio by 9.2% in model 4 (7.9% and 8.9% in model 5 and 6). In addition, the household motorcycle fleet size influenced the life span of the sampled motorcycle. The only motorcycle and two motorcycles being owned in a household raised the disposal hazard of the sampled motorcycle. For example, the hazard increased by 21.6% and 30.3% respectively in model 6. Household car size also increased the scrapped hazard for the sample motorcycle. No cars and only one car in a household raised the hazard by 30.3% and 16.9% as compared with those having three cars or more in a household. Owners with monthly income less than 30,000 NT dollars reduced the hazard of scrapping their motorcycles than that of their counterparts with higher monthly income by 13.8%, 11.8%, and 15.5% in the three respective models. In addition, motorcycles registered in

Greater Taipei had a higher life span and the scrapped hazard declined by 35.1% in model 5.

3. Aggregate attributes

The aggregate variables were used to examine the propensity of disposing of motorcycles associated with socioeconomic conditions and motorcycle inspection performance within specific areas, in which the sampled motorcycles were registered. As previously mentioned, a group of socioeconomic variables and two measurements of regional motorcycle inspection performance were applied to formulate three different models.

In model 4, an increase in unemployment rate of 1% reduced the hazard ratio for motorcycle disposal on average by 31.3%. In addition, a 1% increase in consumption propensity raised the hazard ratio by 5.1%. Increasing district's motorcycle or passenger car density had no association with the scrapped hazard. Engel's coefficient did not show any significant effect on the disposal hazard as well.

Since the average CO and HC emission values were highly correlated with the ineligibility rate (with correlation coefficients of 0.99 and 0.89 respectively), these variables were excluded from model 5 to avoid the problem of multicollinearity. Two of the three predictors of regional motorcycle inspection performance had significant association with the disposal hazards. The inspection rate in a district revealed no association with the district's hazard rate for motorcycle disposal. The increase of 1% of the ineligibility rate in a district reduced the hazard by 7.6% for motorcycle scrappage, thus extending the life span of motorcycles in that district. In addition, the increase of inspection station density by one station per 10 thousands motorcycles serviced reduced the disposal hazard by 26.1% in the district.

Using the dichotomous clusters of regional inspection performance previously discussed, model 6 shows that the districts with better inspection performance had a 37.0% higher disposal hazard ratio after controlling for all other predictors.

Table 10 Cox Regression Results for Motorcycle Scrappage Age

Independent variables	Model 4			Model 5			Model 6		
	β	(S.E.)	e^{β}	β	(S.E.)	e^{β}	β	(S.E.)	e^{β}
Used motorcycle	1.206[a]	(0.130)	3.339	1.175[a]	(0.129)	3.239	1.221[a]	(0.128)	3.391
Age of motorcycle purchased	-0.155[a]	(0.016)	0.856	-0.152[a]	(0.016)	0.859	-0.152[a]	(0.016)	0.859
CC(1)	1.247[a]	(0.217)	3.479	1.263[a]	(0.217)	3.537	1.197[a]	(0.216)	3.311
CC(2)	1.024[a]	(0.210)	2.784	1.070[a]	(0.210)	2.916	0.993[a]	(0.209)	2.698
Sex	×	×	×	×	×	×	×	×	×
Holder's age	-0.024[a]	(0.003)	0.976	-0.024[a]	(0.003)	0.976	-0.023[a]	(0.003)	0.977
Running mileage	×	×	×	×	×	×	×	×	×
Maintenance costs	0.088[b]	(0.037)	1.092	0.076[b]	(0.037)	1.079	0.085[b]	(0.037)	1.089
Household motorcycle size(1)	0.174[c]	(0.096)	1.190	0.152	(0.097)	1.165	0.196[b]	(0.096)	1.216
Household motorcycle size(2)	0.273[a]	(0.080)	1.314	0.245[a]	(0.080)	1.278	0.265[a]	(0.080)	1.303
Household car size(1)	0.245[b]	(0.103)	1.278	0.250[b]	(0.103)	1.284	0.265[a]	(0.102)	1.303
Household car size(2)	0.154[c]	(0.091)	1.166	0.154[c]	(0.091)	1.166	0.156[c]	(0.090)	1.169
Monthly income	-0.149[b]	(0.072)	0.862	-0.125[c]	(0.072)	0.882	-0.169[b]	(0.072)	0.845
Greater Taipei	×	×	×	-0.432[a]	(0.140)	0.649	×	×	×
Unemployment rate	-0.375[a]	(0.055)	0.687	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Motorcycle density	×	×	×	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Passenger car density	×	×	×	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Consumption propensity	0.049[a]	(0.009)	1.051	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Engel's coefficient	×	×	×	N.A.	N.A.	N.A.	N.A.	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.	-0.079[a]	(0.010)	0.924	N.A.	N.A.	N.A.
Inspection station density	N.A.	N.A.	N.A.	-0.302[b]	(0.146)	0.739	N.A.	N.A.	N.A.
Inspection performance cluster	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.315[a]	(0.073)	1.370
Number of observations	7,174			7,174			7,174		
Censored observations (rate)	6,348 (88.5%)			6,348 (88.5%)			6,348 (88.5%)		
LL(β)	-6049.7			-6049.2			-6071.5		
LL(0)	-6209.4			-6209.4			-6209.4		
Degrees of freedom	13			14			12		

Notes: 1. The standard errors (S.E.) of the estimated parameters are listed in parentheses.
2. e^{β} represents the contribution to hazard rate of changing one unit independent variable at a time.
3. [a] denotes that the parameter is significantly different from 0 at α=0.01, [b] at α=0.05, and [c] at α=0.1.
4. "×" represents that the parameter is not significant; "N.A." means "not applicable".

5.2.3 Age of Second-hand Motorcycle Purchased

In this study, whether a "latest transfer" record was observed before the MOTC's sampling time can distinguish a new or a used motorcycle being owned at the initial holding. The age of a used motorcycle at the moment of buying can also be identified. The following Cox regression models were estimated to explore the age of used motorcycles being owned and the possible determinants using two sets of aggregate variables (Table 11).

Table 11 Cox Regression Results for Age of Used Motorcycle at Purchase

Independent variables	Model 7			Model 8		
	β	(S.E.)	e^{β}	β	(S.E.)	e^{β}
CC(1)	1.259 [a]	(0.149)	3.522	1.191 [a]	(0.149)	3.290
CC(2)	1.293 [a]	(0.143)	3.644	1.205 [a]	(0.143)	3.337
Sex	-0.241 [a]	(0.051)	0.786	-0.259 [a]	(0.052)	0.772
Holder's age	-0.005 [a]	(0.002)	0.995	-0.005 [a]	(0.002)	0.995
Running mileage	0.002 [a]	(0.001)	1.002	0.002 [a]	(0.001)	1.002
Maintenance costs	0.059 [b]	(0.025)	1.061	0.060 [b]	(0.025)	1.062
Household motorcycle size(1)	0.249 [a]	(0.064)	1.283	0.262 [a]	(0.064)	1.300
Household motorcycle size(2)	0.222 [a]	(0.052)	1.248	0.199 [a]	(0.052)	1.220
Household car size(1)	-0.169 [a]	(0.066)	0.845	-0.108 [c]	(0.067)	0.898
Household car size(2)	-0.003	(0.058)	0.997	0.026	(0.058)	1.027
Monthly income	×	×	×	-0.100 [b]	(0.048)	0.905
Greater Taipei	×	×	×	0.189 [b]	(0.077)	1.208
Unemployment rate	0.159 [a]	(0.035)	1.173	0.148 [a]	(0.034)	1.159
Motorcycle density	×	×	×	×	×	×
Passenger car density	×	×	×	×	×	×
Consumption propensity	×	×	×	0.012 [c]	(0.007)	1.012
Engel's coefficient	×	×	×	×	×	×
Inspection rate	0.027 [a]	(0.007)	1.027	N.A.	N.A.	N.A.
Ineligibility rate	-0.020 [b]	(0.005)	0.980	N.A.	N.A.	N.A.
Inspection station density	-0.653 [a]	(0.083)	0.520	N.A.	N.A.	N.A.
Inspection performance cluster	N.A.	N.A.	N.A.	×	×	×
Number of observations	2,009			2,009		
Censored observations (rate)	0 (0%)			0 (0%)		
LL(β)	-13132.8			-13155.3		
LL(0)	-13277.6			-13277.6		
Degrees of freedom	14			14		

Notes: 1. The standard errors (S.E.) of the estimated parameters are listed in parentheses.
2. e^{β} represents the contribution to hazard rate of changing one unit independent variable at a time.
3. [a] denotes that the parameter is significantly different from 0 at α=0.01, [b] at α=0.05, and [c] at α=0.1.
4. "×" represents that the parameter is not significant; "N.A." means "not applicable".

1. Vehicle attributes

Of the used motorcycles being owned, engine capacities less than 50 cc and ranging from 51 to 150 cc both had a higher hazard as compared with that of motorcycles greater than 150 cc (3.52 and 3.64 times in model 7, and 3.29 and 3.34 times in model 8 respectively), but no obvious difference between the two categories lower than 150 cc. This means that owners tend to hold a shorter age of used motorcycles less than 150 cc, but a prominently higher age for used motorcycles larger than 150 cc.

2. Usage attributes

Male owners possessed a used motorcycle survived longer than that of females' (0.77-0.79 times the hazard of females in both models). Older holders tended to own a used motorcycle aged more than their young counterparts in both models. For each additional year in the holder's age, the hazard decreased by around 0.5%. A higher running mileage needed associated with a used motorcycle with lower age at purchase (the hazard increase by 0.2%). The increase in maintenance costs by 2.72 times (i.e. equal to one unit increase by taking log) increased the hazard ratio by 6.1-6.2% in the two respective models. The increase of the household motorcycle fleet size extended the age of a sampled second-hand motorcycle. The only motorcycle and two motorcycles being owned in a household raised the hazard by 28.3% and 24.8% respectively in model 7 (30.0% and 22.0% in model 8), indicating a shorter age of a second-hand motorcycle purchased as compared with those households having three motorcycles or more. On the contrary, households having no cars reduced the hazard by 15.5% and 10.2% compared with households having two cars or more in the two respective models. Owners with monthly income less than 30,000 NT dollars, however, increased the age of their used motorcycles at the initial holding than that of their counterpart owners with higher monthly income (9.5% of hazard ratio decreased in model 8). In addition, second-hand motorcycles registered in Greater Taipei had been bought newer (a hazard of 20.8% higher) than those of outside this area in model 8.

3. Aggregate attributes

An increase in unemployment rate of a district associated positively with the hazard ratio. A 1% increase of unemployment rate raised the hazard by 17.3% and 15.9% in the two respective models. Motorcycle and passenger car density in an area had no association with the hazard. A 1% increase in consumption propensity raised the hazard ratio by 1.2% in model 8. District's motorcycle and passenger car density revealed no association with the age of second-hand motorcycle purchased and the same went for district's Engel's coefficient.

All the three predictors of regional motorcycle inspection performance in model 7 showed significant association with the hazards. A 1% increase in the inspection rate and ineligibility rate in a district raised the district's hazard by 2.7% and decreased by 2.0% respectively. In addition, the increase of inspection station density by one station per 10 thousands motorcycles serviced reduced the disposal hazard by 52.0% in the district. As for the dichotomous clusters of regional inspection performance in model 8, districts with better inspection performance, however, were not associated with the age of used motorcycles purchased.

5.3 Estimated Results for Split-population Duration Model

5.3.1 Motorcycle Ownership Duration

To examine the split-population effect resulted from the censored data, pooled events were used to estimate the holding duration. Three duration models－a standard Weibull without the inclusion of censored data, a standard Weibull with censored data, and a split-population Weibull duration model were separately established in this study. The Weibull duration model was employed in accordance with the assumption of hazard dependence with time, which was assumed that the hazard rate of motorcycle ownership termination increased over time (i.e. shape parameter, P >1). In order to overcome the fact that some observations would never experience termination, the split-population duration model using the Weibull hazard form was introduced. The split-population model allowed us to examine the proportion (i.e. split parameter, δ) of eventual observation failures and make corrections to the corresponding estimations.

The estimated results for the three models are demonstrated in Table 12 (the log-survival time form) and Table 13 (the log-hazard form). The scale parameter σ in Table 11 are 0.437, 0.463, and 0.422 for the three models respectively, which can be transformed into the corresponding shape parameters (2.286, 2.158, and 2.367 in Table 12). The shape parameter for the three models were all significantly greater than 1 at α=0.01. This revealed the fact that the instantaneous hazard of motorcycle termination was growing at a slightly increasing rate (i.e. P>2). In addition, the split parameter was statistically significant at less than 1, equaling 0.792 in the split-population model. The proportion pointed out that around 79% of all observations would eventually experience registration termination and in contrast, 21% would perhaps never undergo such an event. Without considering the censored data, the median survival time for motorcycle holding was only 7.61 (model 9s). However, after correcting some unusual prolonged censored data by the split-population duration model, the median survival time for motorcycle holding was reduced from 14.62 years (model 10s) to 12.33 years (model 11s).

The corresponding parameters for the independent variables in Table 11 were estimated by log-survival time form. The notation e^{β^*} represents the ratio of survival time by changing one unit independent variable at a time. For example, a used motorcycle at the initial holding had 0.66 times the holding duration of a new motorcycle in model 11s. In terms of hazard ratio, however, a used motorcycle had 2.69 times the hazard of a new motorcycle in model 11h of Table 13. For convenience of comparison with the hazard-based Cox regression results in Table 9, results in Table 13 were checked. Comparing model 1 (Cox regression) with model 10h (Standard Weibull duration) of the same estimation data, both models had very similar estimated results in the statistical significance and the magnitude of hazard ratio. If model 10h was further compared to split-population model (model 11h), the estimated parameters in both models had the same directions and similar effects on hazard ratios and most of the estimated parameters in the split-population model appeared to slightly expand the contribution effect on hazard ratios.

The comparisons of survivor function and hazard function among the three different duration models are shown in Figure 3 and Figure 4 respectively. After eliminating part of the censored observations in the standard Weibull model, the split-population method raised the hazard and reduced the survival probability of ending a motorcycle holding.

Table 12 Standard Weibull and Split-population Regression Results for Motorcycle Holding Duration (log-survival time form)

Independent variables	Model 9s (Standard model without censoring)		Model 10s (Standard model with censoring)		Model 11s (Split-population model)	
	$\beta^{*}\times10^{-2}$ (S.E.$\times10^{-2}$)	$e^{\beta^{*}}$	$\beta^{*}\times10^{-2}$ (S.E.$\times10^{-2}$)	$e^{\beta^{*}}$	$\beta^{*}\times10^{-2}$ (S.E.$\times10^{-2}$)	$e^{\beta^{*}}$
Used motorcycle	-42.321 [a] (3.364)	0.655	-42.344 [a] (3.042)	0.655	-41.787 [a] (3.219)	0.658
Age of motorcycle purchased	-3.441 [a] (0.449)	0.966	-2.246 [a] (0.388)	0.978	-2.795 [a] (0.423)	0.972
CC(1)	-61.186 [a] (7.210)	0.542	-51.419 [a] (6.692)	0.598	-57.838 [a] (6.940)	0.561
CC(2)	-53.103 [a] (6.939)	0.588	-40.673 [a] (6.544)	0.666	-45.944 [a] (6.738)	0.632
Sex	5.382 [a] (2.392)	1.055	× ×	×	× ×	×
Holder's age	1.229 [a] (0.079)	1.012	1.585 [a] (0.079)	1.016	1.579 [a] (0.081)	1.016
Running mileage	-0.105 [a] (0.014)	0.999	-0.068 [a] (0.015)	0.999	-0.081 [a] (0.016)	0.999
Maintenance costs	-6.077 [a] (1.023)	0.941	-6.198 [a] (1.094)	0.940	-6.733 [a] (1.130)	0.935
Household motorcycle size(1)	-4.817 [c] (2.683)	0.953	× ×	×	× ×	×
Household motorcycle size(2)	× ×	×	-4.412 [b] (2.236)	0.957	× ×	×
Household car size(1)	× ×	×	-7.578 [a] (2.792)	0.927	-6.898 [b] (2.922)	0.933
Household car size(2)	× ×	×	× ×	×	× ×	×
Monthly income	-5.188 [a] (1.931)	0.949	× ×	×	× ×	×
Greater Taipei	× ×	×	× ×	×	9.003 [b] (4.357)	1.094
Unemployment rate	× ×	×	5.210 [a] (1.533)	1.053	3.553 [b] (1.620)	1.036
Motorcycle density	0.083 [a] (0.024)	1.001	0.125 [a] (0.021)	1.001	0.156 [a] (0.023)	1.002
Passenger car density	0.219 [a] (0.049)	1.002	0.214 [a] (0.045)	1.002	0.268 [a] (0.049)	1.003
Consumption propensity	-0.608 [c] (0.321)	0.994	-1.275 [a] (0.329)	0.987	-1.275 [a] (0.338)	0.987
Engel's coefficient	× ×	×	× ×	×	× ×	×
Constant	251.094 [a] (33.289)	—	287.541 [a] (32.310)	—	257.527 [a] (33.312)	—
σ	0.437 [d] (0.007)	—	0.463 [d] (0.008)	—	0.422 [d] (0.008)	—
δ	— —	—	— —	—	0.792 [d] (0.021)	—
Number of observations	2,143		7,148		7,148	
Censored observations (rate)	0 (0%)		5,005 (70.0%)		5,005 (70.0%)	
LL(β)	-1547.3		-4364.9		-4337.2	
LL(0)	-2097.1		-5488.8		-5488.8	
Median survival time (years)	7.61		14.62		12.33	

Notes: 1. The standard errors (S.E.) of the estimated parameters are listed in parentheses.

2. e^{β} represents the ratio of survival time by changing one unit independent variable at a time.

3. [a] denotes that the parameter is significantly different from 0 at α=0.01, [b] at α=0.05, and [c] at α=0.1.

4. "×" represents the parameter is not significant; "N.A." means "not applicable".

5. [d] denotes that σ and δ is significantly larger than and less than 1 at α=0.01, respectively.

Table 13 Standard Weibull and Split-population Regression Results for Motorcycle Holding Duration (log-hazard form)

Independent variables	Model 9h (Standard model without censoring)		Model 10h (Standard model with censoring)		Model 11h (Split-population model)	
	β ×10⁻²	e^{β}	β ×10⁻²	e^{β}	β ×10⁻²	e^{β}
Used motorcycle	0.968 [a]	2.634	0.915 [a]	2.496	0.990 [a]	2.692
Age of motorcycle purchased	0.079 [a]	1.082	0.049 [a]	1.050	0.066 [a]	1.068
CC(1)	1.400 [a]	4.056	1.111 [a]	3.036	1.371 [a]	3.938
CC(2)	1.215 [a]	3.371	0.878 [a]	2.407	1.089 [a]	2.970
Sex	-0.123 [b]	0.884	×	×	×	×
Holder's age	-0.028 [a]	0.972	-0.034 [a]	0.966	-0.037 [a]	0.963
Running mileage	0.002 [a]	1.002	0.001 [a]	1.001	0.002 [a]	1.002
Maintenance costs	0.139 [a]	1.149	0.134 [a]	1.143	0.160 [a]	1.173
Household motorcycle size(1)	0.110 [c]	1.117	×	×	×	×
Household motorcycle size(2)	×	×	0.095 [b]	1.100	×	×
Household car size(1)	×	×	0.164 [a]	1.178	0.163 [b]	1.178
Household car size(2)	×	×	×	×	×	×
Monthly income	0.1199 [a]	1.126	×	×	×	×
Greater Taipei	×	×	×	×	-0.213 [b]	0.808
Unemployment rate	×	×	-0.113 [a]	0.894	-0.084 [b]	0.919
Motorcycle density	-0.002 [a]	0.998	-0.003 [a]	0.997	-0.004 [a]	0.996
Passenger car density	-0.005 [a]	0.995	-0.005 [a]	0.995	-0.006 [a]	0.994
Consumption propensity	0.014 [c]	1.014	0.028 [a]	1.028	0.030 [a]	1.031
Engel's coefficient	×	×	×	×	×	×
Constant	-5.746 [a]	—	-6.210 [a]	—	-11.943 [a]	—
P	2.286 [d]	—	2.158 [d]	—	2.367 [d]	—
δ	—	—	—	—	0.792 [d]	—

Notes: 1. The standard errors (S.E.) of the estimated parameters are listed in parentheses.
2. e^{β} represents the hazard ratio by changing one unit independent variable at a time.
3. [a] denotes that the parameter is significantly different from 0 at α=0.01, [b] at α=0.05, and [c] at α=0.1.
4. "×" represents the parameter is not significant; "N.A." means "not applicable".
5. [d] denotes that P and δ is significantly larger than and less than 1 at α=0.01, respectively.

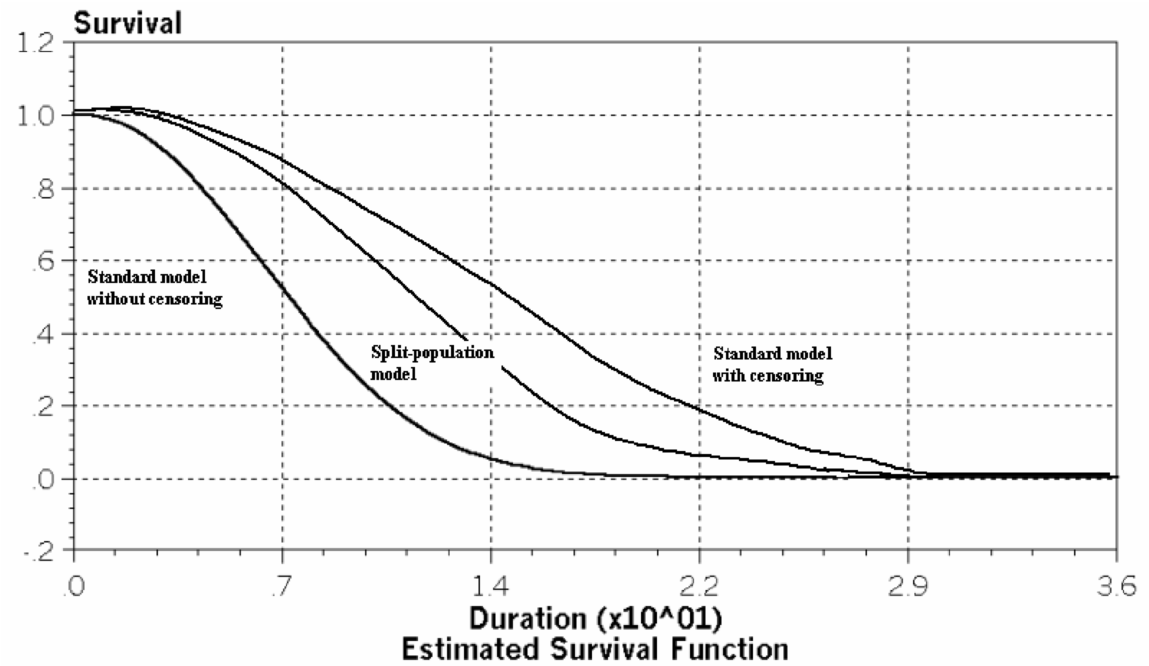

Figure 3 Survivor Functions for Motorcycle Holding Duration among Models

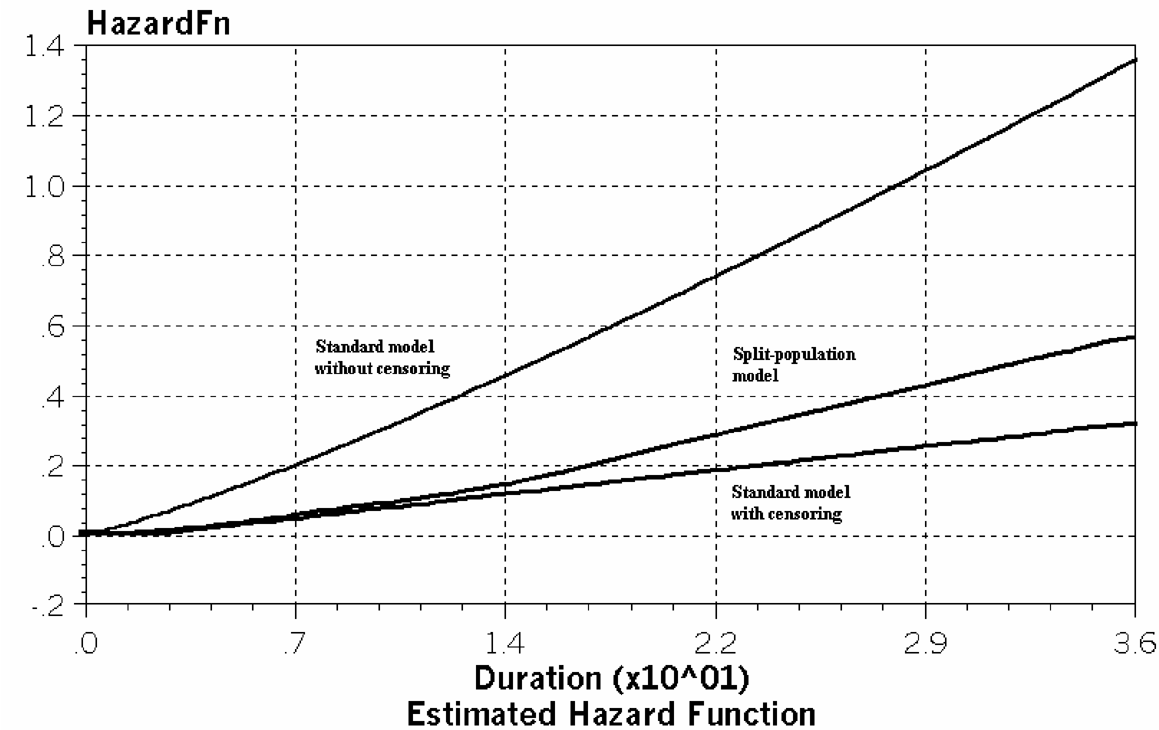

Figure 4 Hazard Functions for Motorcycle Holding Duration among Models

5.3.2 Motorcycle Scrappage Age

Similar to holding duration models, a standard Weibull without the inclusion of censored data, a standard Weibull with censored data, and a split-population Weibull duration model were separately estimated for the motorcycle scrappage age. The estimated results for the three models are demonstrated in Table 14 (the log-survival time form) and Table 15 (the log-hazard form).

The scale parameter σ in Table 14 were 0.247, 0.270, and 0.215 for the three models respectively, which can be transformed into the corresponding shape parameters (4.041, 3.697, and 4.648 in Table 15). The shape parameter for the three models were all significantly greater than 1 at $\alpha=0.01$. This revealed the fact that the instantaneous hazard of motorcycle termination was increasing at an increasing rate (i.e. $P>2$). The split parameter was statistically significant at less than 1, equaling 0.533 in the split-population model. The proportion indicated that around 53% of all observations would eventually experience disposal registration and in contrast, as much as 47% would perhaps never undergo the disposal event. Only considering the disposal events, the median survival time for motorcycle scrappage age was 12.91 (model 12s). However, after correcting some unusual prolonged censored data by the split-population method, the median survival time for motorcycle scrappage age was reduced from 20.89 years (model 13s) to 15.94 years (model 14s).

The hazard ratios contributed by the independent variables in Table 14 were also very similar with the Cox regression results in Table 10. Using model 4 and model 5 (Cox regression) to compare with model 13h (Standard Weibull duration), the three models had very similar estimated results in the statistical significance and the magnitude of hazard ratios, except for the engine capacity, sex, and Greater Taipei variables. Specifically, model 13h indicated that the hazard ratios inflated to 5.29 (equal to and lower than 50cc) and 3.87 (51-150cc) times as compared with motorcycle 150cc or more respectively. Male holders had less hazard (0.85) than females to dispose of their motorcycles in the Weibull model, but was not significant in the Cox models. Motorcycles registered in Greater Taipei, however, reduced the hazards to 0.41 as compared with model 5 (0.65) in Table 10.

Using model 13h to further compare to the split-population model (model 14h), the estimated parameters in both models also had the same directions and similar effects on hazard ratios and most of the estimated parameters in the split-population model appeared to slightly expand the contribution effect on hazard ratios, except for sex, motorcycle fleet size in a household, monthly income, Engel's coefficient, and inspection station density.

Table 14 Standard Weibull and Split-population Regression Results for Motorcycle Scrappage Age (log-survival time form)

Independent variables	Model 12s(Standard model without censoring)			Model 13s (Standard model with censoring)			Model 14s (Split-population model)		
	β^* ×10^{-2}	(S.E.×10^{-2})	e^{β^*}	β^* ×10^{-2}	(S.E.×10^{-2})	e^{β^*}	β^* ×10^{-2}	(S.E.×10^{-2})	e^{β^*}
Used motorcycle	-39.558 ^{a}	(4.642)	0.673	-34.257 ^{a}	(3.478)	0.710	-31.594 ^{a}	(3.364)	0.729
Age of motorcycle purchased	4.795 ^{a}	(0.675)	1.049	4.033 ^{a}	(0.447)	1.041	4.369 ^{a}	(0.448)	1.045
CC(1)	-33.306 ^{a}	(7.688)	0.717	-44.992 ^{a}	(5.564)	0.638	-40.826 ^{a}	(5.727)	0.665
CC(2)	-24.282 ^{a}	(7.251)	0.784	-36.539 ^{a}	(5.367)	0.694	-32.776 ^{a}	(5.504)	0.721
Sex	×	×	×	4.439 ^{b}	(2.108)	1.045	×	×	×
Holder's age	0.497 ^{a}	(0.066)	1.005	0.643 ^{a}	(0.072)	1.006	0.551 ^{a}	(0.070)	1.006
Running mileage	×	×	×	×	×	×	×	×	×
Maintenance costs	-2.206 ^{b}	(0.967)	0.978	-1.761 ^{c}	(0.978)	0.983	×	×	×
Household motorcycle size(1)	×	×	×	-5.370 ^{b}	(2.492)	0.948	×	×	×
Household motorcycle size(2)	×	×	×	-8.567 ^{a}	(2.053)	0.918	-4.678 ^{b}	(1.927)	0.954
Household car size(1)	×	×	×	-4.882 ^{c}	(2.687)	0.952	-4.448 ^{c}	(2.473)	0.956
Household car size(2)	×	×	×	×	×	×	×	×	×
Monthly income	×	×	×	4.802 ^{b}	(1.890)	1.049	×	×	×
Greater Taipei	19.927 ^{a}	(6.065)	1.221	23.803 ^{a}	(4.812)	1.269	28.300 ^{a}	(4.997)	1.327
Unemployment rate	3.365 ^{b}	(1.699)		8.351 ^{a}	(1.484)	1.087	6.221 ^{a}	(1.461)	1.064
Motorcycle density	×	×	×	×	×	×	×	×	×
Passenger car density	0.155 ^{a}	(0.047)	1.002	0.157 ^{a}	(0.041)	1.002	0.180 ^{a}	(0.042)	1.002
Consumption propensity	-0.888 ^{c}	(0.342)	0.991	-1.577 ^{a}	(0.311)	0.984	-1.601 ^{a}	(0.293)	0.984
Engel's coefficient	×	×	×	0.869 ^{b}	(0.430)	1.009	×	×	×
Inspection rate	×	×	×	×	×	×	×	×	×
Ineligibility rate	1.160 ^{a}	(0.334)	1.012	1.823 ^{a}	(0.355)	1.018	1.720 ^{a}	(0.326)	1.017
Inspection station density	×	×	×	15.012 ^{a}	(4.122)	1.162	8.447 ^{b}	(4.092)	1.088
Constant	285.478 ^{a}	(38.186)	—	337.797 ^{a}	(33.386)	—	313.524 ^{a}	(32.677)	—
σ	0.247 ^{d}	(0.006)	—	0.270 ^{d}	(0.007)	—	0.215 ^{d}	(0.005)	—
δ	—	—	—	—	—	—	0.533 ^{d}	(0.022)	—
Number of observations	822			7,174			7,174		
Censored observations (rate)	0 (0%)			6,352 (88.5%)			6,352 (88.5%)		
LL(β)	-119.5			-1662.3			-1598.1		
LL(0)	-306.9			-4938.9			-4938.9		
Median survival time (years)	12.91			20.89			15.94		

Notes: 1. The standard errors (S.E.) of the estimated parameters are listed in parentheses.

2. e^{β} represents the ratio of survival time by changing one unit independent variable at a time.

3. ^{a} denotes that the parameter is significantly different from 0 at α=0.01, ^{b} at α=0.05, and ^{c} at α=0.1.

4. "×" represents the parameter is not significant; "N.A." means "not applicable".

5. ^{d} denotes that σ and δ is significantly larger than and less than 1 at α=0.01, respectively.

Table 15 Standard Weibull and Split-population Regression Results for Motorcycle Scrappage Age (log-hazard form)

Independent variables	Model 12h(Standard model without censoring)		Model 13h (Standard model with censoring)		Model 14h (Split-population model)	
	β ×10^-2	e^{β}	β ×10^-2	e^{β}	β ×10^-2	e^{β}
Used motorcycle	1.602 [a]	4.961	1.269 [a]	3.557	1.469 [a]	4.347
Age of motorcycle purchased	-0.194 [a]	0.824	-0.149 [a]	0.861	-0.203 [a]	0.816
CC(1)	1.348 [a]	3.851	1.667 [a]	5.293	1.899 [a]	6.678
CC(2)	0.983 [a]	2.673	1.353 [a]	3.870	1.524 [a]	4.593
Sex	×	×	-0.164 [b]	0.848	×	×
Holder's age	-0.020 [a]	0.980	-0.024 [a]	0.976	-0.026 [a]	0.975
Running mileage	×	×	×	×	×	×
Maintenance costs	0.089 [b]	1.093	0.065 [c]	1.067	×	×
Household motorcycle size(1)	×	×	0.199 [b]	1.220	×	×
Household motorcycle size(2)	×	×	0.317 [a]	1.373	0.218 [b]	1.243
Household car size(1)	×	×	0.181 [c]	1.198	0.207 [b]	1.230
Household car size(2)	×	×	×	×	×	×
Monthly income	×	×	-0.178 [b]	0.837	×	×
Greater Taipei	-0.807 [a]	0.446	-0.882 [a]	0.414	-1.316 [a]	0.268
Unemployment rate	-0.136 [b]	0.873	-0.309 [a]	0.734	-0.289 [a]	0.749
Motorcycle density	×	×	×	×	×	×
Passenger car density	-0.006 [a]	0.994	-0.006 [a]	0.994	-0.008 [a]	0.992
Consumption propensity	0.036 [a]	1.037	0.058 [a]	1.060	0.074 [a]	1.077
Engel's coefficient	×	×	-0.032 [b]	0.968	×	×
Inspection rate	×	×	×	×	×	×
Ineligibility rate	-0.047 [a]	0.954	-0.068 [a]	0.935	-0.080 [a]	0.923
Inspection station density	×	×	-0.556 [a]	0.573	-0.393 [b]	0.675
Constant	-11.558 [a]	—	-12.511 [a]	—	-14.583 [a]	—
P	4.056 [d]	—	3.704 [d]	—	4.651 [d]	—
δ	—	—	—	—	0.533 [d]	—

Notes: 1. The standard errors (S.E.) of the estimated parameters are listed in parentheses.

2. e^{β} represents the hazard ratio by changing one unit independent variable at a time.

3. [a] denotes that the parameter is significantly different from 0 at α=0.01, [b] at α=0.05, and [c] at α=0.1.

4. "×" represents the parameter is not significant; "N.A." means "not applicable".

5. [d] denotes that P and δ is significantly larger than and less than 1 at α=0.01, respectively.

The survivor function and hazard function among the three different duration models are compared in Figure 5 and Figure 6 respectively. After eliminating part of the censored observations in the standard Weibull model, the split-population method raised the hazard and reduced the survival probability of scrapping a motorcycle.

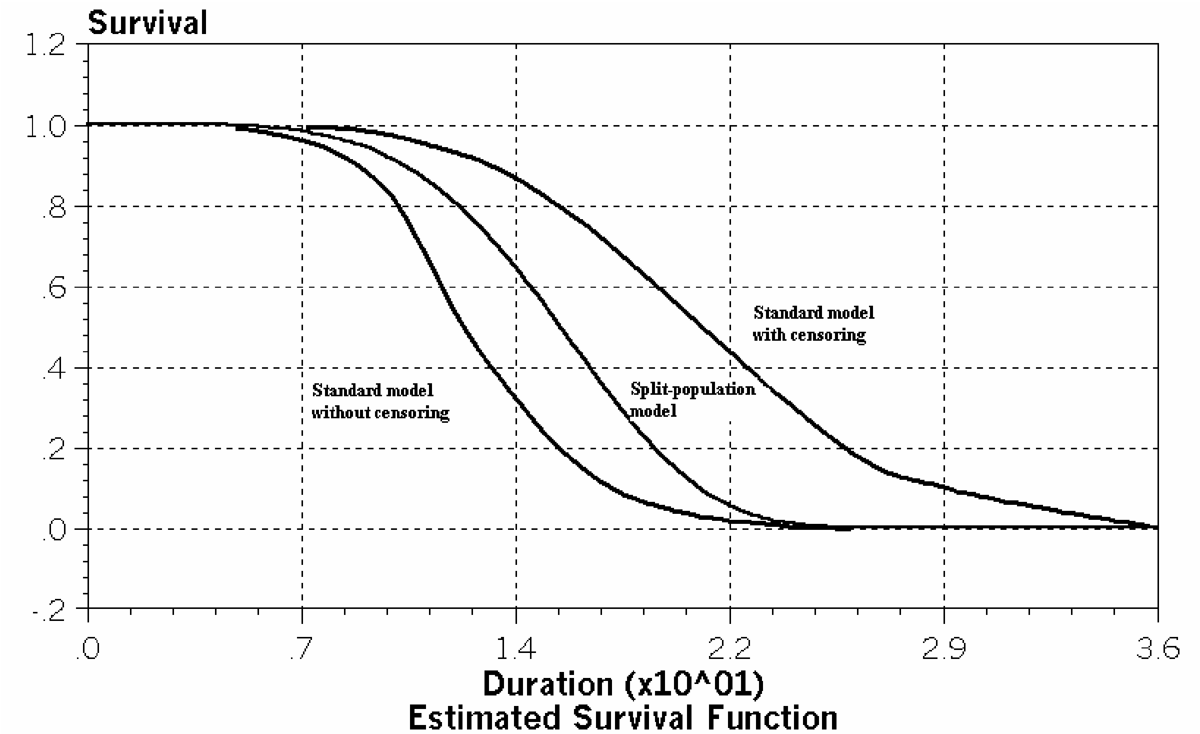

Figure 5 Survivor Functions for Motorcycle Scrappage Age among Models

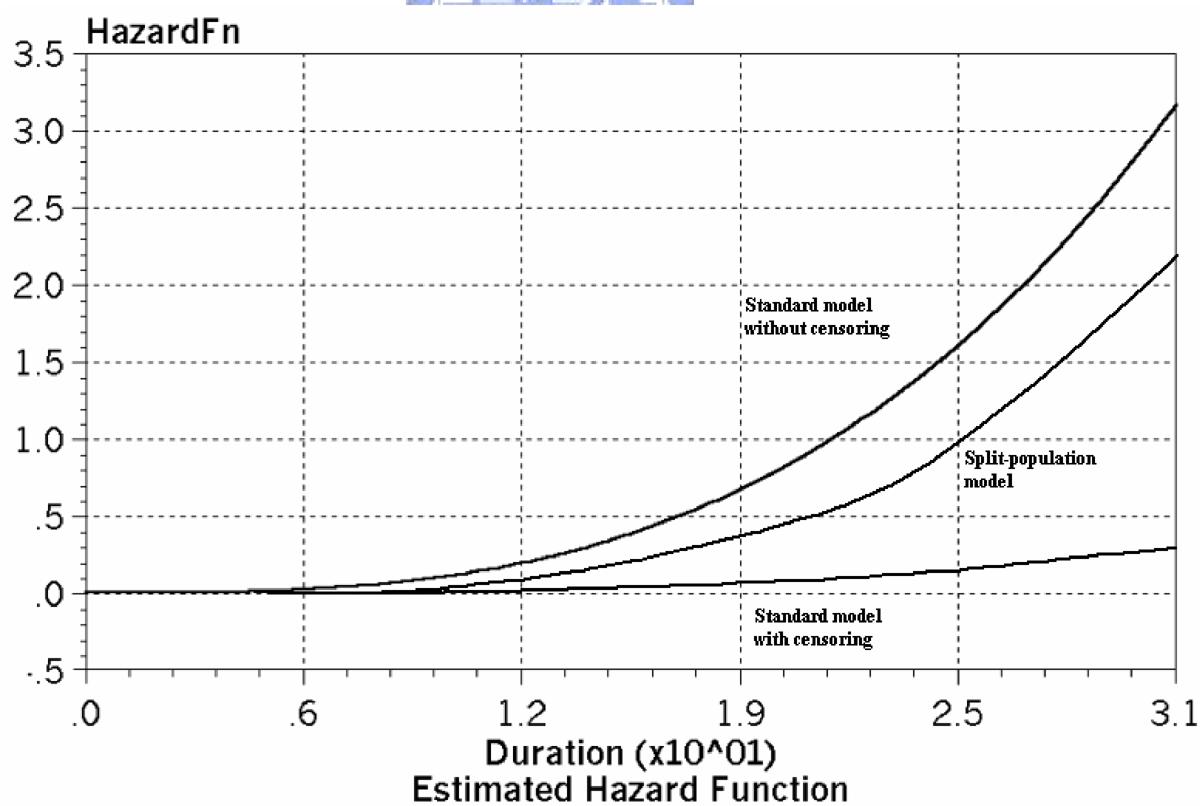

Figure 6 Hazard Functions for Motorcycle Scrappage Age among Models

5.4 Estimated Results for Logistic Regression Model

5.4.1 Disposal/Transfer Event

The two competing risks for motorcycles being disposed of and being transferred may have different occurrence possibility associated with various influence factors. The logistic regression model (disposal event = 1) was applied to distinguish the odds between these two risks (Table 16).

1. Vehicle attributes

A used motorcycle did not show any association with ending motorcycle holding by disposal or by transfer. The age of motorcycle holding at MOTC's sampling time, however, showed a significant association with the competing risks. A one year holding age increase for a motorcycle raised the odds ratio of scrapping over transferring a motorcycle by 21.1%. Lower engine sized motorcycles also raised the disposal odds. The disposal odds ratio increased to 6.03 times (≦ 50cc) and 5.83 times (51-150cc) as compared with motorcycle larger than 150cc respectively.

2. Usage attributes

Sex factor had no association with the two types of competing risks. For each additional year increase in the holder's age, the odds ratio of disposing of a motorcycle raised by 1.6%. A one kilometer increase per week reduced the possibility of a motorcycle being disposed of by 0.2%. Maintenance costs did not show any association with the odds of disposing of or transferring a motorcycle. Household motorcycle size associated with the risk types of ending a motorcycle ownership. Being the only motorcycle and two motorcycles in a household had around 1.56 and 1.46 times the odds respectively to end the sampled motorcycle by disposal compared with those of three motorcycles or more in a household. Household's car size, owners' monthly income, and motorcycle registered in Greater Taipei showed no significant effect on the odds ratios, however.

3. Aggregate attributes

An increase in unemployment rate by 1% in a district decreased the odds of scrapping a motorcycle by 21.5%. The other four socioeconomic factors including passenger car density, motorcycle density, consumption propensity, and Engel's coefficient of a district did not show any association with these two competing risks of ending ownership.

Table 16 Logistic Regression Results for Competing Risks

Independent variables	Model 15	
	β (S.E.)	e^{β}
Used motorcycle	× ×	×
Age of motorcycle holding *	0.192[a] (0.012)	1.211
CC(1)	1.797[a] (0.348)	6.033
CC(2)	1.764[a] (0.344)	5.833
Sex	× ×	×
Holder's age	0.016[a] (0.004)	1.016
Running mileage	-0.002[b] (0.001)	0.998
Maintenance costs	× ×	×
Household motorcycle size(1)	0.443[a] (0.135)	1.557
Household motorcycle size(2)	0.381[a] (0.112)	1.463
Monthly income	× ×	×
Greater Taipei	× ×	×
Unemployment rate	-0.243[a] (0.069)	0.785
Motorcycle density	× ×	×
Passenger car density	× ×	×
Consumption propensity	× ×	×
Engel's coefficient	× ×	×
Constant	-3.947 (0.467)	—
Number of events	2,176	
Number of disposal events	826	
Number of transfer events	1,350	
LL(β)	-1208.9	
LL(0)	-1444.8	
Degrees of freedom	8	

Notes: 1. The standard errors (S.E.) of the estimated parameters are listed in parentheses.
2. e^{β} represents the contribution to hazard rate of changing one unit independent variable at a time.
3. [a] denotes that the parameter is significantly different from 0 at α=0.01, [b] at α=0.05, and [c] at α=0.1.
4. "×" represents that the parameter is not significant; "N.A." means "not applicable".
5. "Age of motorcycle holding" defined as motorcycle in-use age at the time of MOTC's sampling.

5.4.2 Used/New Motorcycle Purchased

The logistic regression model (used motorcycle = 1) was applied to establish the relationship between the likelihood of a used vs. a new motorcycle purchased and their determinants (Table 17).

Table 17 Logistic Regression Results for Used/New Motorcycle Holding

Independent variables	Model 16			Model 17		
	β	(S.E.)	e^{β}	β	(S.E.)	e^{β}
CC(1)	-0.313[c]	(0.179)	0.732	-0.311[c]	(0.179)	0.733
CC(2)	-0.375[b]	(0.174)	0.687	-0.370[b]	(0.174)	0.691
Sex	0.403[a]	(0.060)	1.497	0.405[a]	(0.060)	1.499
Holder's age	-0.008[a]	(0.002)	0.992	-0.009[a]	(0.002)	0.991
Running mileage	-0.002[a]	(0.001)	0.998	-0.001[a]	(0.0003)	0.999
Maintenance costs	0.083[a]	(0.030)	1.086	0.084[a]	(0.030)	1.088
Household motorcycle size(1)	-0.217[a]	(0.073)	0.805	-0.209[a]	(0.073)	0.811
Household motorcycle size(2)	-0.093	(0.060)	0.911	-0.092	(0.060)	0.912
Household car size(1)	×	×	×	×	×	×
Household car size(2)	×	×	×	×	×	×
Monthly income	×	×	×	×	×	×
Greater Taipei	-0.729[a]	(0.101)	0.482	-0.504[a]	(0.098)	0.604
Unemployment rate	0.074[c]	(0.042)	1.077	×	×	×
Motorcycle density	×	×	×	×	×	×
Passenger car density	0.005[a]	(0.001)	1.005	0.005[a]	(0.001)	1.005
Consumption propensity	0.047[a]	(0.009)	1.048	0.045[a]	(0.008)	1.047
Engel's coefficient	×	×	×	×	×	×
Inspection rate	×	×	×	N.A.	N.A.	N.A.
Ineligibility rate	×	×	×	N.A.	N.A.	N.A.
Inspection station density	-0.176[c]	(0.103)	0.838	N.A.	N.A.	N.A.
Inspection performance cluster	N.A.	N.A.	N.A.	-0.269[a]	(0.062)	0.764
Constant	-5.098[a]	(0.732)	—	-4.979[a]	(0.730)	—
Number of observations	7,183			7,183		
Number of used motorcycles	2,099			2,099		
Number of new motorcycles	5,174			5,174		
LL(β)	-4167.5			-4162.6		
LL(0)	-4257.1			-4257.1		
Degrees of freedom	13			12		

Notes: 1. The standard errors (S.E.) of the estimated parameters are listed in parentheses.
2. e^{β} represents the contribution to hazard rate of changing one unit independent variable at a time.
3. [a] denotes that the parameter is significantly different from 0 at α=0.01, [b] at α=0.05, and [c] at α=0.1.
4. "×" represents that the parameter is not significant; "N.A." means "not applicable".

1. Vehicle attributes

Engine capacity less than 50 cc and ranging from 51 to 150 cc both had 0.73 and 0.69 times the odds of a used motorcycle being held in the respective two models as compared with that of motorcycles greater than 150 cc. The results indicated that motorcycle engine capacity larger than 150cc showed a higher likelihood of being used at the moment of purchase.

2. Usage attributes

Male motorcycle owners had a 50% more possibility to possess a used motorcycle than females in both models. Each additional year in the holder's age, the odds ratio reduced by around 0.8-0.9% in the two models. One kilometer increase per week reduced the possibility of a motorcycle being a second-hand one by 0.1-0.2% in the two models. The increase in maintenance costs by 2.72 times (i.e. equal to one unit increase by taking log) raised the odds of being a used motorcycle by 8.6-8.8% at the moment of buying in both models. Household motorcycle size also associated with the motorcycle used status at buying. Being the only motorcycle in a household, the sampled motorcycle had a 0.81 times the odds of being a used motorcycle as compared with three motorcycles or more in a household. Household car size, however, showed no association with the likelihood of buying a used motorcycle. Also, owners' monthly income showed no association with the used status of motorcycles purchased. In addition, motorcycles registered in Greater Taipei revealed a less likelihood of being a used motorcycle (0.48 and 0.60 times the odds in model 16 and model 17 respectively).

3. Aggregate attributes

An increase in unemployment rate of 1% in a district inflated the odds of second-hand motorcycle ownership by 7.7% in model 16. Increasing vehicle density in an area by one passenger car per thousand persons raised the second-hand likelihood by 0.5%, but no contribution by district's motorcycle density. A 1% increase in consumption propensity also raised the odds of being a used motorcycle by 4.7-4.8% in both models. Increase of district's inspection station density by one station per 10 thousands motorcycles serviced reduced the odds of purchasing a used motorcycle by 16.2% in model 16. Districts with better inspection performance using a cluster measurement had only 0.76 times the odds of holding a used motorcycle in model 17. Engel's coefficient, inspection rate, and ineligibility rate, however, did not show any association with the used status of motorcycles being owned at the initial holding in model 16 and Engel's coefficient had no association as well in model 17.