



A dynamic analysis of motorcycle ownership and usage: A panel data modeling approach

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ABSTRACT

This study aims to develop motorcycle ownership and usage models with consideration of the state dependence and heterogeneity effects based on a large-scale questionnaire panel survey on vehicle owners. To account for the independence among alternatives and heterogeneity among individuals, the modeling structure of motorcycle ownership adopts disaggregate choice models considering the multinomial, nested, and mixed logit formulations. Three types of panel data regression models – ordinary, fixed, and random effects – are developed and compared for motorcycle usage. The estimation results show that motorcycle ownership in the previous year does exercise a significantly positive effect on the number of motorcycles owned by households in the current year, suggesting that the state dependence effect does exist in motorcycle ownership decisions. In addition, the fixed effects model is the preferred specification for modeling motorcycle usage, indicating strong evidence for existence of heterogeneity. Among various management strategies evaluated under different scenarios, increasing gas prices and parking fees will lead to larger reductions in total kilometers traveled.

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1. Introduction

In many Asian countries such as China, Indonesia, Malaysia, Taiwan, Thailand, and Vietnam, motorcycles are a primary mode of urban transportation. Due to low purchase and running costs and convenient parking, demand for motorcycles has continuously risen in these countries. Traffic congestion, accidents, parking disorder, and air pollution are the inevitable consequences of high rates of motorcycle ownership and usage. Especially, in the context of accident analysis, because of limited protection design of motorcycles in comparison to cars, motorcycles are the most dangerous form of motorized transport, with injury rates eight times, and fatality rates 35 times that of car occupants (per vehicle mile traveled) (NHTSA, 2007; Ranney et al., 2010). In most developed countries, motorcycle fatalities typically comprise around 5–18% of overall traffic fatalities (Mohan, 2002; Koornstra et al., 2003; WHO, 2006). This proportion reflects the relatively low ownership and usage of motorcycles in many developed countries. However, the ownership and usage of motorcycles and other two-wheelers is generally relatively high in many developing countries. Reflecting this difference, the levels of motorcyclist fatalities as a proportion of those injured on the roads are typically higher in developing countries than in developed countries. For example, in India, 69%

of the total number of motor vehicles are motorized two-wheelers (Mohan, 2002) and 27% of road deaths in India are among users of motorized two-wheelers, while this figure is between 70% and 90% in Thailand, and about 60% in Malaysia (Mohan, 2002; Umar, 2002; Suriyawongpaisal and Kanchanusut, 2003). In China, motorcycles accounted for 23.4% of all registered motor vehicles in 1987, increasing to 63.2% in 2001. Motorcyclist fatalities and injuries increased 5.5-fold and 9.3-fold between 1987 and 2001, respectively. A total of 7.5% of all traffic fatalities and 8.8% of all traffic injuries were sustained by motorcyclists, with the corresponding proportions increasing to 18.9% and 22.8% in 1987 and 2001, respectively. The changing proportions of both traffic fatalities and injuries sustained by motorcyclists were positively correlated with the change in the proportion of motorcycles among all motor vehicles (Zhang et al., 2004). In Indonesia, the population of motorcycles has reached 78.3% of total motor vehicles and 75% fatality victims of traffic accidents were motorcyclists (Indriastuti and Sulistio, 2010). In Taiwan, the motorcycle ownership rate reaches 645 per thousand people (the highest motorcycle ownership rate in the world). In 2009, motorcyclist fatalities in Taiwan accounted for 56.69% of total traffic deaths (MOTC, 2010). To compare the fatalities and injuries of car and motorcycle crashes further, Tables 1 and 2, respectively give the statistics of car and motorcycle ownership, usage and crash victims of 23 counties/cities in Taiwan. Noted from Table 1, there are a total of 5.7 million registered passenger cars with 502 fatalities and 71,564 injuries in 2009, while the number of registered motorcycles reaches 14.6 million with 889 fatalities

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Table 1
Car ownership, usage and crash of 23 counties/cities in Taiwan.

County/city	Registered cars	Average kilometers traveled (km)	Total kilometers traveled (million veh-km)	Victims		Fatalities (million veh-km)	
				Victims	Fatalities (million veh-km)	Victims	Injuries (million veh-km)
Taipei city	637,354	9842	6273	28	0.005	5908	0.942
Kaohsiung city	367,265	9734	3575	17	0.005	8023	2.244
Taipei county	776,945	8694	6755	20	0.003	6093	0.902
Yilan county	111,717	8987	1004	19	0.019	1988	1.980
Taoyuan county	535,501	9636	5160	49	0.010	7437	1.441
Hsinchu county	152,342	9157	1395	16	0.011	2007	1.438
Miaoli county	159,682	7152	1142	26	0.023	1605	1.406
Taichung county	438,394	8908	3905	36	0.009	6668	1.708
Changhwa county	343,522	8978	3084	26	0.009	4509	1.462
Nantou county	147,459	10,035	1480	19	0.013	1644	1.111
Yunlin county	179,534	8901	1598	34	0.021	2006	1.255
Chiayi county	134,520	8437	1135	29	0.026	1242	1.094
Tainan county	287,513	8198	2357	31	0.013	3561	1.511
Kaohsiung county	298,871	7783	2326	41	0.018	4140	1.780
Pingtung county	194,016	7582	1471	25	0.017	2230	1.516
Taitung county	49,223	7354	362	13	0.035	710	1.963
Hualien county	84,012	9701	815	22	0.027	1379	1.692
Ponhu county	18,047	7702	139	3	0.023	141	1.016
Keelung city	77,898	8010	624	6	0.010	847	1.358
Hsinchu city	114,352	10,057	1150	11	0.009	1886	1.640
Taichung city	316,596	8936	2829	12	0.004	3969	1.403
Chiayi city	69,624	7900	550	8	0.015	1769	3.217
Tainan city	190,162	9744	1853	11	0.006	1799	0.971
Average	–	8758	–	–	0.014	–	1.524
Total	5,684,549	–	50,982	502	–	71,564	–

and 129,200 injuries in Table 2. Even in terms of accident rates (i.e., number of victims per million kilometers traveled), motorcycle usage (in terms of total kilometers traveled) still exhibits higher rates of fatal and injured victims than car usage. On an average, there are 0.017 fatalities and 2.038 injuries per million kilometers traveled by motorcycles in comparison to 0.014 fatalities and 1.524 injuries per million kilometers traveled by cars. To further

examine the relationship between motorcycle usage and numbers of victims of two severity levels, the Pearson correlation test is performed. Results show that correlation coefficients of motorcycle usage with fatalities and injuries are 0.586 (p -value = 0.003) and 0.886 (p -value < 0.0001), respectively, indicating a significant and positive correlation between motorcycle usage and crash victims. Compared with the relationship between motorcycle usage and

Table 2
Motorcycle ownership, usage, and crashes of 23 counties/cities in Taiwan.

County/city	Registered motorcycles	Average kilometers traveled (km)	Total kilometers traveled (million veh-km)	Fatalities		Injuries	
				Victims	Fatalities (million veh-km)	Victims	Injuries (million veh-km)
Taipei city	1,092,788	4438	4850	24	0.005	9513	1.962
Kaohsiung city	1,207,026	4778	5768	41	0.007	14,950	2.592
Taipei county	2,259,828	4912	11,099	66	0.006	13,600	1.225
Yilan county	292,879	4730	1385	34	0.024	3064	2.212
Taoyuan county	1,081,978	4665	5047	47	0.009	9919	1.965
Hsinchu county	271,233	4769	1293	35	0.027	2844	2.200
Miaoli county	350,202	3800	1331	23	0.018	2117	1.591
Taichung county	1,008,400	4199	4234	59	0.014	12,121	2.863
Changhwa county	902,353	4220	3807	62	0.016	8245	2.166
Nantou county	349,862	3883	1359	34	0.025	2888	2.125
Yunlin county	486,157	4308	2094	58	0.028	3384	1.616
Chiayi county	365,747	4597	1681	43	0.025	2123	1.263
Tainan county	805,813	4580	3691	57	0.015	7594	2.058
Kaohsiung county	1,014,396	5119	5192	79	0.015	9968	1.920
Pingtung county	697,431	4697	3276	86	0.026	5462	1.667
Taitung county	177,999	4006	713	30	0.042	1579	2.215
Hualien county	241,958	4472	1082	28	0.025	2435	2.251
Ponhu county	68,426	4125	282	4	0.014	585	2.074
Keelung city	190,771	4569	872	11	0.013	1653	1.895
Hsinchu city	262,338	4307	1130	16	0.014	3507	3.103
Taichung city	646,739	3813	2466	23	0.010	6127	2.484
Chiayi city	202,586	4961	1005	11	0.011	2312	2.300
Tainan city	583,436	4885	2850	17	0.006	3210	1.126
Average	–	4471	–	–	0.017	–	2.038
Total	14,560,346	–	66,509	889	–	129,200	–

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