Helmet Use and Motorcycle Fatalities in Taiwan

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Abstract

Crash data from Taiwan provides a unique opportunity to study the effectiveness of helmets on saving lives because motorcycle deaths account for more than half of total traffic fatalities on the island. This study uses accident-specific data between 1999 and 2001 to estimate the effectiveness of helmets, simultaneously taking into account sample selection bias and other risk factors. The results show that sample selection does not seriously bias the estimate and helmets reduce the death rate by 50 percent which is higher than previously found. Without helmet use, the total number of motorcyclists killed in 2001 would have jumped by more than 70 percent. The estimated proportion of motorcyclists wearing a helmet has increased from 76% to 84% between 1999 and 2001. Hence, nearly one third of the decrease in motorcycle fatalities can be attributed to rising helmet use. Taiwan's implementation of the mandatory helmet law since 1997 has significantly reduced motorcycle fatalities. The estimated marginal willingness to pay for reduction in fatality risks in 2001 is close to $US723.

Keywords: Helmet, Motorcycle fatalities, Willingness to pay, Taiwan.

Introduction

Traffic accidents have jumped to becoming the leading cause of death for people in Taiwan over the past 10 years. Though the death rate of traffic accidents per

100,000 people has dropped from 35.4 in 1991 to 19.2 in 2002, it remains one of the highest among developing and developed countries. For example, in 1999 the death rate of traffic accidents was 15.1 for the U.S., 7.7 for Germany, 7.0 for Japan, and 22.3 for South Korea. In Taiwan there were 1,563 motorcyclists killed and 84,242 wounded in 2002 alone. Head injuries cause 67 percent of these deaths (1,048 people) and non-helmeted riders account for one third of motorcycle fatalities. Figure 1 shows the death rate of traffic accidents in Taiwan between 1991 and 2002. The death rate remained stable before 1995 and has begun to decrease since then.

What makes Taiwan unique for studying the efficacy of helmet usage is that unlike the U.S. and other western countries, motorcycles are the most popular choice of transportation for short and medium-range commutes in Taiwan. The proportion of motorcycles for registered motor vehicles is the highest in all countries that have been studied. By the end of 2002, there were 17,906,957 registered vehicles and 68 percent of them were motorcycles. Moreover, motorcycle fatalities accounted for 54 percent of total traffic deaths in 2002. On the other hand, the percentages of motorcycle deaths in total traffic fatalities are only 7.6, 15.8, and 15.9 in the U.S., Germany, and South Korea. Though Taiwan government has implemented a mandatory helmet law since 1997, the proportion of unhelmeted drivers still remains high (25%). Consequently, analyzing the efficacy of helmet usage from Taiwan’s data is valuable. The benefits of saving lives will be substantial and the enforcement of the helmet law can be justified if helmets significantly reduce the probability of injuries or deaths for motorcyclists.

Although previous studies have shown that a mandatory helmet law can effectively reduce fatality rates (fatalities per accident, fatalities per capita, etc.), there are a few problems with them. First, the majority of these studies use cross-sectional or time-series aggregate data. The drawback of using aggregate data is that risk factors associated with the motorcyclist and the accident cannot be observed and controlled. Second, for studies employing accident specific data, the way that their data were collected may lead to a sample selection problem, which results in biased estimates. Sample selection arises because in the data set we only observe traffic accidents involving either a fatality or an injury. If safety devices such as a helmet or seat belt can prevent an individual from being killed or injured on the road, then this individual will not be included in the data set and the estimates of the effectiveness of the device will be downward biased.

This study uses accident-specific data in Taiwan between 1999 and 2001 to estimate the effectiveness of helmets in preventing traffic deaths, simultaneously taking into account sample selection bias and risk factors such as age, gender, speed limit, and weather conditions. The remainder of the paper is organized as follows. Section II reviews past research. Section III discusses empirical specification and section IV gives the introduction of the sample and the definitions of variables. Section V shows empirical results and discusses their implications. The final section concludes the paper.

Literature Review

Previous research mainly examines the effect of the enforcement or the repeal of helmet laws on fatalities at the aggregate level. NHTSA (2002) evaluates the repeal of helmet laws in Kentucky and Louisiana by simply comparing the motorcyclist fatalities before and after the repeal without controlling for other risk factors. The results suggest that the rates of fatalities per registered motorcycle rose by 37% in Kentucky and 75% in Louisiana following the repeals. Graham and Lee (1986) and De Wolf (1986) both use data from 1975-1984 and employ a fixed effect model as a control for factors that may have changed over time or vary across states and affect motorcyclist fatalities. Graham and Lee find that helmet laws reduce total fatalities by 20 percent and fatalities per registered motorcycle by 11 to 13 percent. De Wolf suggests that helmet laws lower fatalities per accident by 18 percent. The common problem in these studies is that except for time- and state-specific effects, they do not account for other factors that may influence motorcyclist fatalities.

Sass and Leigh (1991) argue that the helmet laws are endogenous because the number of motorcyclists and their risk preferences in a state can influence both whether the state will adopt a helmet law and the fatality rates. Consequently, the states self-select into either the “helmet law” group or “no helmet law” group. After accounting for the endogeneity of the helmet law, they find that the difference in motorcyclist fatalities per capita for states with and without helmet laws drops significantly from 14.3 percent to 0.4 percent. Sass and Zimmerman (2001) use data from 1976-1997 and set up a two-way fixed effects model to control for possible omitted variables that might affect both the motorcyclist fatalities and the legislation of the helmet law. Their results show that on average, helmet laws reduce annual per capita motorcyclist fatalities by 29 to 33 percent. They also find that a 10 percent increase in alcohol consumption per capita and a 10 percent decrease in police employment per capita lead to a 5 percent increase in motorcycle fatalities.

Only limited studies use accident-specific data to examine the effect of helmet usage on motorcyclist fatalities. Using a sample of 900 motorcycle accidents in the Los Angels area in 1976 and 1977, Goldstein (1986) employs tobit model to examine the effect of helmet use on the probability of fatality and the severity of head and neck injuries. He controls for variables such as the presence of alcohol, age, and rider's kinetic energy prior to the crash because they might affect the level of injury and also systematically differ between helmeted and non-helmeted riders. He finds that helmet use does not significantly lower the probability of fatality and has ambiguous effects on the severity of head injuries. Evans and Frick (1988) apply double-pair comparison method to the FARS data for 1975 through 1986. To control for the dependence of survivability on sex and age, they limit the data to crashes in which the drivers are male and the driver and the passenger's age do not differ by more than 3 years. Then they calculate two ratios: (1) the ratio of driver fatalities to passenger fatalities in crashes in which the driver wears a helmet and the passenger and (2) the ratio of driver fatalities to passenger fatalities in crashes in which neither wears a helmet. The ratio of the first ratio to the second ratio provides a measure of helmet effectiveness. They find that helmets are 20 to 36 percent effective in preventing fatalities for motorcycle riders. The fatality risk for drivers is 26 percent higher than that for passengers. Furthermore, the estimated increase in rider fatalities due to helmet law repeal is close to 20%.

Weiss (1992) estimates the effect of helmet use on the level of head injury using ordinal Probit and Goldstein's data set. He chooses not to estimate the fatality rate for two reasons. He recognizes the problem of sample selection because the data come from emergency service systems and therefore only riders with injuries are available. Second, fatalities can result from injuries to parts of the body not protected by a helmet. His results suggest that helmet use leads to a 42 percent increase in the number of motorcyclists with no head injuries and a $1,700 per rider decrease in medical costs of treating the motorcyclists.

Levitt and Porter (2001) evaluate the effectiveness of seatbelt and airbag using data on fatal crashes in the U.S. between 1994 and 1997. They propose a solution to the problem of sample selection by limiting the sample to crashes in which someone in the other vehicle died. Their results show that, after accounting for sample selection, seat belts are more effective and air bags are less effective than previously found. Wearing a seatbelt reduces the likelihood of death by 60 percent, while air bags reduce the probability of death by 16 percent. They estimate nearly 15,000 lives were saved by seat belt usage in 1997.

Ever since Peltzman's (1975) seminal paper, a number of studies have attempted to measure the magnitude and existence of the offsetting behavior. Nonetheless, their findings are mixed and hence the validity of the moral hazard hypothesis remains controversial. Some researchers (Evens and Graham, 1991; Garbacz, 1991, 1992a, a992b; Chirinko and Harper, 1993; Peterson et al. 1995; Chalkins and Zlatoper, 2001) support the hypothesis by showing that the offsetting behavior of motor vehicle drivers and the implementation of seat belt/helmet laws significantly increase the fatality rate of non-occupants (pedestrians and motorcyclists). On the other hand, Garbacz (1990) and Robertson (1996) fail to document the existence of the offsetting effect.

Empirical Model and Data

The likelihood of a motorcyclist being involved in a fatal crash can be presented by the following function:

$$\Pr(Death) = f\left(Helmet, X, Y, Z\right), \qquad (1)$$

where *Helemt* indicates whether the motorcyclist wears a safety helmet, and X, Y, and Z represent vectors of individual, crash–specific, and vehicle-specific characteristics that influence the probability of a fatal crash, respectively. Equation (2) lays out the empirical specification of the probability model:

$$\begin{aligned} P(Y_{ijc} = 1) = {} & \beta_0 + \beta_1 HELEMT_{ijc} + \beta_2 OLDER30_{ijc} + \beta_3 MALE_{ijc} \\ & + \beta_4 YR00_{ijc} + \beta_4 YR01_{ijc} + \beta_6 WEATHER_{ijc} + \beta_7 NIGHT_{ijc} \qquad (2) \\ & + \beta_8 SPEED50_{ijc} + \beta_9 HEAD_{ijc} + \beta_{10} URBAN_{ijc} + \beta_{11} CAR_{ijc} + \varepsilon_{ijc} \end{aligned}$$

Here, *i* represents a particular rider, *j* indicates a specific vehicle, *c* indexes a given crash, and ε_{ijc} is the error term. *Y* is an indicator equal to one if the motorcyclist is killed in the crash and zero otherwise, while *HELMET* measures helmet usage in the accident.

The model also controls three levels of risk factors that might affect the probability of death in a crash. The first level consists of individual characteristics including gender (*MALE*) and age (*OLDER30*). The second level accounts for crash characteristics such as year of occurrence (*YR00*, *YR01*), time of occurrence (*NIGHT*), place of occurrence (*RURAL*), weather condition (*WEATHER*), head or neck injury (*HEAD*), and speed limit (*SPEED50*). How well a safety device functions depends on the severity of the crash. Hence, the final group of variables is vehicle-specific such as the type of vehicle the motorcyclist crashed into (*CAR*). Since we do not observe the severity of the crash, the speed limit and the type of vehicle crashed into are both used as proxies. A logit model is used in estimation due to its ease of interpretation. Standard errors of the estimates are corrected for heteroskedasticity.

Although the use of a safety device influences the likelihood of injury and death, which in turn determines whether a crash is included in the sample, I expect that the problem of sample selection in estimating helmet effectiveness is less severe than in seatbelt effectiveness. Unlike seatbelts which protect a large part of a driver’s body, helmets can only prevent or reduce head injuries for motorcyclists in accidents. Given that motorcyclists in traffic accidents usually suffer multiple injuries, the effect of helmet use on the probability of a crash being included in the sample should be limited. In the following empirical results, I report estimates for the full sample and the sample with the selection controlled.

The data for this study are from the Traffic Accident Files (TAF) for the period 1999-2001 provided by the National Police Agency, Ministry of Interior. TAF collects all reported traffic accidents involving an injury or fatality in Taiwan. The files consist of two types of traffic accidents: A1 traffic accidents are those in which either the vehicle occupants or pedestrians died on the scene or within 24 hours of the accident; A2 traffic accidents include those involving injuries only. The TAF contains detailed crash information such as the location, time and day of the crash, the weather condition under which the crash occurred, speed limit, and types of vehicle involved in the crash. The characteristics of vehicle occupants or pedestrians, such as age, gender, educational attainment, seat belt and helmet usage, severity of injury, alcohol involvement, and license types, are also available in TAF.

I limit the sample of analysis in the following ways. One-vehicle crashes are deleted because we need the status of injuries of the driver or rider in the other vehicle for the correction of sample selection. In addition, except for the driver or rider, TAF does not distinguish which vehicle the passengers were sitting in. As a result, the study focuses only on estimating the risk of fatality for the motorcycle rider. Traffic accidents involving large vehicles such as coach buses, semi trucks, trailers, and trains are also deleted because in these most severe crashes, helmets are completely ineffective. We also delete traffic accidents in which either party of the accident is bicyclists or pedestrians. Finally, we delete observations with missing values.

The full sample contains 107,631 observations and the sample selection contains 26,452 observations. Tables 1 and 2 report the definitions and summary statistics for the variables used in the analysis. The significant decline in the number of observations for correcting selection bias is due to the exclusion of accidents involving motorcycles and cars. The full sample shows 69 percent of cases in which motorcyclists crashed into cars, while the percentage drops to 5 percent in sample selection. This shows that car-motorcycle crashes impose limited risk to car drivers.

Empirical Results and Discussions

I present empirical results under different specifications for the full sample and the sample with selection bias correction in Table 3. All the coefficients of explanatory variables have expected signs and are statistically significant at the 5 percent level. Consistent with earlier predictions, the problem of sample selection does not impose a significant impact on the estimate of helmet effectiveness. The coefficient of helmet remains unchanged after controlling for sample selection. Consequently, I will use specification (1) for the discussion follows. In addition, specification 2 indicates that the magnitude of the coefficient of helmet decreases by 33 percent after crash severity (CAR) and head and neck injury (HEAD) are included in the regression model. This suggests that without controlling for the severity of the impact and injured body parts, the estimates of helmet effectiveness will be biased.

The results show that helmet usage significantly reduces the probability of motorcycle fatalities. The odds for unhelmeted motorcyclists to be killed on the road are 1.68 times greater than helmeted motorcyclists. Based on the estimates in the full sample model, a one percent increase in helmet use decreases the probability of death by 0.21 percent, indicating that the elasticity of probability of motorcycle fatalities is inelastic with respect to helmet usage. We can interpret the regression results more informatively by calculating the fraction of lives saved through the use of a helmet. It is defined as e_H, the ratio of the reduction in probability of fatalities due to helmet use to the probability of death without wearing a helmet, which can easily be obtained from the logit regression. After normalizing the coefficient, a helmet turns out to be quite effective in reducing fatalities. Off the probability of death for those not wearing helmets, helmets reduce the death rate by 50 percent. The findings suggest that helmets are more effective than previous estimates suggest (30%).

Other covariates capture factors affecting the probability of fatalities. Motorcyclists older than 30 years old are 1.9 times more likely to be killed in an accident, other things equal. The death rate is higher for male motorcyclists, 1.75 higher. Head and neck injuries positively and significantly increase the likelihood of death. The death rate for motorcyclists with head or neck injuries is 7 times higher than their counterparts' for the full sample and 10 times higher for the sample controlled for selection. The severity of the crash is approximated by variable CAR, the types of vehicle one crashes into. Motorcycle riders crashing into a passenger car or pickup truck are 4 times more likely to be killed than those crashing into a motorcycle. The odds increase to almost 17 times when sample selection is controlled. Consistent with previous studies, the chance of death is higher during the night, in rural areas, and on roads with a speed limit of 50 kilometers per hour. Furthermore, there appears a decreasing trend in the probability of death between 1999 and 2001.

Number of lives saved

Given e_H, we can estimate the number of lives saved through the use of helmets and the fraction of motorcyclists wearing a helmet. Let us define K_H and K_0 as the number of motorcyclists who were killed with and without a helmet, respectively. The number of lives saved through the use of helmets can then be expressed as $(e_H/(1-e_H))K_H$. Table 4 presents the fraction of lives saved through helmet use in 2001. There were 423 unhelmeted motorcyclists and 1,140 helmeted motorcyclists killed in 2001 alone. Given $e_H = 0.5$, the number of lives saved through helmet use in 2001 is 1,140. That is, without a helmet, the total number of motorcyclists killed in 2001 would jump by more than 70 percent.

Effect on fatality risks associated with head injuries

Head injury is the leading cause of death in motorcycle fatalities. This subsection examines the effect of helmets on fatality risks associated with head injuries. I limit the sample to crashes in which the drivers' main injuries are head injuries. If wearing a helmet can reduce the severity of head injury, the fatality risk associated with head injury for helmeted drivers should be lower than that for unhelmeted drivers, given a head injury occurs. I estimate equation (2) using head injury sample and report only the fraction of lives saved in Table 4. The results suggest that helmets effectively lower the likelihood of death among drivers with head injuries. The fatality risks for helmeted drivers died due to head injuries are 0.67 times of that for unhelmeted drivers. In the other words, helmets effectively reduce the death rate by 41 percent. Given that there were 721 helmeted motorcyclist died due to head injuries in 2001. Without helmets, the total number of motorcyclist death caused by head injuries would have been 1,531.

Proportion of motorcyclists wearing a helmet

We also can estimate the fraction of motorcyclists wearing a helmet using e_H, K_H, and K_0. The fraction can be expressed as $[(K_H/(1-e_H))/((K_H/(1-e_H))+K_0)]$. Based on the numbers in 2001, the helmet usage rate was 85 percent in 2001, and 81 percent and 76 percent in 2000 and 1999, respectively. Although helmets are effective in saving lives, rising helmet use among motorcyclists alone is not enough to account for the observed decreasing trend in motorcycle fatalities. The number of motorcycle fatalities declined by 6 percent between 1999 and 2001. Based on the elasticity (0.21) obtained above, a 9 percent increase in the helmet usage rate contributes to a decrease in the death toll by 1.9 percent. That is, nearly one third of the decrease in motorcycle fatalities may be attributed to rising helmet use on the road. The implementation of a mandatory helmet law since 1997 in Taiwan has significantly reduced motorcycle fatalities.

Marginal willingness to pay (MWTP)

Following Freeman (1993), the marginal willingness to pay for a motorcyclist to purchase a helmet can be estimated given the predicted reduction in the probability of a fatality due to helmet use and the cost of a helmet. The MWTP is defined as:

$$MWTP = \frac{annualized\ \cos t\ of\ a\ helmet}{probability\ reduction\ in\ fatality\ due\ to\ wearing\ a\ helemt}. \qquad (3)$$

The cost of a helmet includes the purchase price, time, and disutility costs. For simplicity, I assume that the disutility and time costs are zero. Consequently, the estimated MWTP here is a lower bound of the true MWTP.

The market prices for helmets vary widely ranging from $US4 to $US138.[1] The average price of a helmet cannot be obtained without knowing the percent of the population who buys expensive versus inexpensive helmets. I use $US13 as the market price of a helmet because it is the price an average consumer pays to buy a helmet at local discount stores.[2] In addition, the manufacturers recommend replacing helmets after 3 to 5 years. Hence, I assume the helmet life is 4 years. The annualized cost of a helmet is given by $p*(r/(1+r))/(1-1/(1+r)^4)$, where p is the market price of a helmet, t is the helmet life, and r is the discount rate (r=0.03). The resulting annualized cost of a helmet is equal to $US3.4. Given that the decrease in the probability of fatality due to a helmet is 0.0047, the MWTP is equal to $US723. That is, for motorcyclists who buy helmets, they are willing to pay at least $US723 for a reduction in fatality risks.

Conclusion

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[1] The exchange rate for Taiwan and the U.S. currencies was $NT36 per U.S. dollar in 2001.

[2] The discount stores in Taiwan are similar to Wal-Mart, Target, and Costco in the U.S.

This paper presents an estimate of the effectiveness of helmets in preventing deaths in traffic accidents. I use accident-specific data from Taiwan and account for the sample selection problem inherent in the data in the regression model. The results show that the sample selection does not significantly bias the estimate of helmet effectiveness in this study. The findings suggest that helmets are quite effective in saving lives. Wearing a safety helmet reduces the probability of death by 50 percent, which is greater than that reported in earlier studies (30%). Based on the estimates, there were 1,140 lives saved by helmets in 2001 alone and a total of 3,332 lives saved between 1999 and 2001. Hence, the benefits of wearing a helmet are substantial, compared with the costs of helmet. For motorcyclists who own a helmet, the marginal willingness to pay for a reduction in the risk of fatality is estimated to be close to $US723.

This study also finds that rising helmet use among motorcyclists are not enough to account for the declines in the number of motorcycle fatalities in Taiwan. During the three-year period, the proportion of motorcyclists wearing helmets increased from 76% to 84%. The rising helmet use accounts for one third of the decrease in motorcycle fatalities during the same time period. This finding provides evidence to the effectiveness of mandatory helmet laws on reducing motorcycle fatalities in Taiwan. It also suggests that factors other than helmets are more important in explaining the decreasing trend.

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Table 1: Definitions of the Variables

Variables	Definition
DEATH	Dichotomous variable equals 1 if the motorcyclist is killed in a traffic accident.
MALE	Dichotomous variable equals 1 if the motorcyclist is male.
OLDER30	Dichotomous variable equals 1 if the motorcyclist is older than 30.
YR00	Year dummy equals 1 if the traffic accident occurred in 2000.
YR01	Year dummy equals 1 if the traffic accident occurred in 2001.
HELMET	Dichotomous variable equals 1 if the motorcyclist wears a helmet.
CAR	Dichotomous variable equals 1 if the motorcyclist crashed into a passenger car or a pickup truck.
WEATHER	Dichotomous variable equals 1 if the weather is rainy, snowy, stormy, or hazy.
NIGHT	Dichotomous variable equals 1 if the traffic accident occurs during the night.
HEAD	Dichotomous variable equals 1 if the major injuries are either head or neck injuries.
RURAL	Dichotomous variable equals 1 if the traffic accident occurs in rural counties.
SPEED50	Dichotomous variable equals 1 if the speed limit of the road is at least 50 kilometers per hour.

Table 2: Sample Means and Standard Deviations

	Full Sample		Selection Bias Sample	
Variables	**Mean**	**Standard Dev.**	**Mean**	**Standard Dev.**
DEATH	0.021	0.14	0.012	0.11
MALE	0.632	0.48	0.701	0.46
OLDER30	0.599	0.49	0.554	0.50
YR00	0.360	0.48	0.365	0.48
YR01	0.460	0.50	0.472	0.50
HELEMT	0.880	0.32	0.862	0.35
CAR	0.691	0.46	0.048	0.21
WEATHER	0.092	0.29	0.071	0.26
NIGHT	0.359	0.48	0.393	0.49
HEAD	0.158	0.36	0.134	0.34
RURAL	0.301	0.47	0.297	0.46
SPEED50	0.312	0.46	0.299	0.46
Number of Obs.	107,632		26,452	

Table 3: Logit Estimates of the Probability of Motorcycle fatalities

	Full Sample		Sample Selection Sample	
Parameters	**(1)**	**(2)**	**(3)**	**(4)**
HELMET	-0.510***	-0.930***	-0.502***	-0.985***
	(0.051)	(0.048)	(0.137)	(0.122)
HEAD	1.960***		2.307***	
	(0.048)*		(0.133)	
CAR	1.348***		2.819***	
	(0.076)		(0.134)	
OLDER25	0.570***	0.653***	0.616***	0.625***
	(0.051)	(0.049)	(0.136)	(0.123)
MALE	0.561***	0.589***	0.362**	0.449***
	(0.054)	(0.053)	(0.155)	(0.143)
WEATHER	0.162***	0.262***	-0.287	0.034
	(0.073)	(0.070)	(0.243)	(0.213)
NIGHT	0.412***	0.438***	0.625***	0.757***
	(0.047)	(0.045)	(0.131)	(0.118)
RURAL	1.951***	2.147***	1.885***	2.402***
	(0.054)	(0.053)	(0.155)*	(0.146)
SPEED50	0.676***	0.758***	0.770***	0.954***
	(0.047)	(0.045)	(0.130)	(0.117)
YR89	-0.729***	-0.811***	-0.860***	-0.854***
	(0.062)	(0.059)	(0.181)	(0.161)
YR90	-1.066***	-1.233***	-0.970***	-1.247***
	(0.063)	(0.060)	(0.180)	(0.162)
INTERCEPT	-6.805***	-4.780***	-6.988***	-5.577***
	(0.119)	(0.090)	(0.287)	(0.246)
Sample size	107,632	107,632	26,452	26,452
Likelihood ratio	5895.37	3657.09	1356.45	637.22
Pseudo R-squared	0.27	0.18	0.39	0.19

Note: standard errors are reported in parentheses.

** statistically significant at the 5% level.

*** statistically significant at the 1% level.

Table 4: Total Number of Lives Saved Through Helmets in 2001

	Full Sample	Head Injury Sample
Fraction of lives saved (1)	0.50	0.41
Number of helmeted motorcyclist deaths (2)	1,140	
Number of helmeted motorcyclist deaths due to head injuries (3)		721
Number of lives saved by helmet[a,b]	1,140	483

a. The number for full sample is calculated as follows: $[(1)/(1-(1))]*(2)$.

b. The number for head injury sample is calculated as follows: $[(1)/(1-(1))]*(3)$.

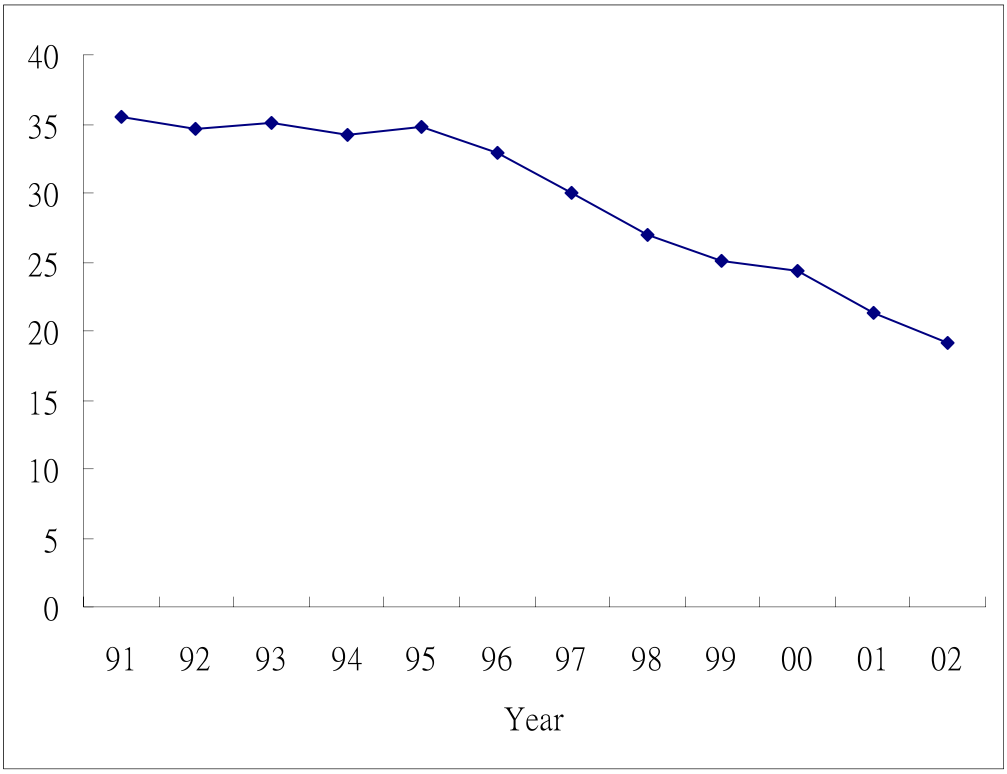

Figure 1: Traffic death rates per 100,000 population between 1991 and 2002 in Taiwan.

Source: National Police Agency, Ministry of Interior, 2002.