ASSESSMENT OF FACTORS AFFECTING SAFETY IN THE TRUCKING INDUSTRY

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Abstract: This paper tries to assess the factors which influence safety in the trucking industry of Metro Manila through a data set obtained from a truck driver survey conducted in 1999. Probit modeling is used to assess the impact of both operational and personal factors that may influence driver safety. The paper also tries to examine whether the existing truck ban in Metro Manila has an effect on the probability that a truck driver will be involved in an accident. Fatigue due to lack of sleeping hours caused by the escalation of nighttime deliveries to mitigate effects of the truck ban can negatively affect performance and alertness of truck drivers and can be a significant determinant of safety. An understanding of the factors can help policy makers in the evaluation of existing demand management measures such as the truck ban which can form the basis of future urban freight transport policies.

Key Words: safety, accident, trucking industry, truck ban, probit modeling

1. INTRODUCTION

Safety in the trucking industry is without a doubt one of the most controversial issues in transportation. Articles on traffic accidents involving trucks appear more and more frequently in the daily newspapers. A quick review of some of these articles will reveal that the major causes of these accidents are usually attributed to mechanical failure, poor driving behavior, driving under the influence of alcohol, sleepiness and fatigue.

The aim of this paper is to provide a better understanding of the factors which influence safety in the trucking industry of Metro Manila. Data obtained from a truck driver survey conducted in 1999 is employed to accomplish this purpose. First, descriptive statistics is used to identify both personal and operational factors that may influence driver safety. Probit modeling is then conducted to assess the impact of the significant variables affecting safety. The paper also tries to examine whether the existing truck ban in Metro Manila has an effect on the probability that a truck will be involved in an accident. The imposition of the truck ban has apparently resulted in the escalation of nighttime deliveries performed by the affected transport companies. This result may have far-reaching consequences on safety since drivers are forced to work overnight. Fatigue due to lack of sleeping hours can negatively affect performance and alertness of drivers and can be a significant determinant of safety in the trucking industry. While safety could potentially be improved immediately by changing key variables identified as significant, an understanding of the factors influencing truck-related accidents in Metro Manila can also help policy makers and planners in the evaluation of existing demand management measures such as the truck ban which can form the basis of future urban freight transport policies.

The paper would first provide information on road accidents in the Philippines and the factors affecting safety in the trucking industry focusing on Metro Manila. This is then followed by the analyses on the impacts of truck ban on safety in Metro Manila. Finally, plausible recommendations based on the findings and conclusions of the study are suggested.

2. ROAD ACCIDENT STATISTICS

A road accident is an occurrence involving a motor vehicle operating on a public road that results in death, bodily injury, or property damage (US DOT, 1996). Road traffic accident records in the Philippines are compiled by the respective regional Traffic Management Groups (TMG) of the Philippine National Police (PNP). These statistics are considered conservative because of unreported cases due to amicable settlements and failure of drivers to report less serious accidents.

Official statistics gathered from the PNP show that there are 10,595 recorded cases of accidents in the Philippines for 1999, classified as fatal (6.8%), non-fatal (20.3%), and damage to property (72.9%). This represents a 16 percent increase from the 9,122 cases reported in 1998. A total of 5,418 persons were directly affected by serious traffic accidents consisting of 969 fatalities and 4,449 serious injuries during 1999. This represents a 4.3 percent increase from the 5,195 casualties recorded in 1998. However, the number of fatalities decreased by 20 percent from the 1,213 fatalities reported the previous year (Table 1).

Table 1. Road accidents in the Philippines for 1998 and 1999

Year	Incidence				Severity		
	Fatal	Non-fatal	Damage	Total	Fatalities	Injuries	Total
1998	940 (10.3)	1,863 (20.4)	6,319 (69.3)	9,122	1,213 (23.3)	3,982 (76.7)	5,195
1999	719 (6.8)	2,150 (20.3)	7,726 (72.9)	10,595	969 (17.9)	4,449 (82.1)	5,418

Source: Traffic Management Group, Philippine National Police (2000)

An examination of the 1999 PNP data in Table 2 reveals that driver error is the primary cause of traffic accidents comprising an overall share of almost 82 percent while the overall share of accidents due to mechanical defect (4.9%) and road defect (2.3%) is only minimal. Other causes including hit-and-run or unsolved cases make up the remainder with an overall share of 11.3 percent. Driver error includes accidents due to drunk driving, over speeding, overloading, bad overtaking, fatigue and falling asleep while driving. Some studies have pointed out that driver errors stem primarily from the lack of discipline and traffic education among drivers of both private and public vehicles (Mendoza, forthcoming). A report from a daily newspaper indicated that a large part of road accidents were caused by the failure of drivers to understand the most basic traffic signs like "no entry" (Inquirer, 2000). Although most accidents are attributed to driver error, it must not be underestimated that safety improvements along the roadway and integrated into the vehicle can decrease the probability of a driver committing a serious error and the occurrence of a crash.

Regions where large urban areas are located have the highest percentages of accidents (Table 2 and Figure 1) as manifested by Metro Manila or the National Capital Region (NCR) with almost 35 percent, Davao in Region 11 with 15 percent, and Cebu in Region 7 with about 13 percent. This result demonstrates that urbanized areas, where population growth and motorization rates are high, face greater safety risks due to increased levels of exposure of the population to motorized traffic. In addition, it can also be deduced that the number of accidents is strongly related to traffic activity and congestion.

Table 2. Cause of accidents by region (1999)

Region	Driver Error		Mechanical Defect		Road Defect		Others		Total	
NCR	2,690	(80.4)	14	(0.4)	32	(1.0)	609	(18.2)	3,345	(34.5)
Region 1	51	(89.5)	5	(8.8)	0	(0.0)	1	(1.8)	57	(0.6)
Region 2	59	(98.3)	1	(1.7)	0	(0.0)	0	(0.0)	60	(0.6)
Region 3	252	(81.3)	31	(10.1)	11	(3.6)	14	(4.6)	308	(3.2)
Region 4	592	(78.3)	71	(9.4)	14	(1.8)	79	(10.4)	756	(7.8)
Region 5	144	(80.0)	12	(6.7)	8	(4.4)	16	(8.9)	180	(1.8)
Region 6	295	(86.3)	36	(10.5)	7	(2.1)	4	(1.2)	342	(3.5)
Region 7	1,141	(91.2)	51	(4.1)	14	(1.1)	45	(3.6)	1,251	(12.9)
Region 8	75	(83.3)	7	(7.8)	0	(0.0)	8	(8.9)	90	(0.9)
Region 9	621	(83.5)	14	(1.9)	4	(0.5)	105	(14.1)	744	(7.7)
Region 10	171	(71.5)	40	(16.7)	9	(3.8)	19	(8.0)	239	(2.4)
Region 11	1,330	(90.8)	57	(3.9)	41	(2.8)	37	(2.5)	1,465	(15.1)
Region 12	135	(46.7)	23	(8.0)	17	(5.9)	114	(39.4)	289	(3.0)
Region 13	160	(49.8)	69	(21.5)	59	(18.4)	33	(10.3)	321	(3.3)
CAR	57	(82.6)	8	(11.6)	3	(4.4)	1	(1.4)	69	(0.7)
ARMM	143	(74.5)	36	(18.8)	3	(2.6)	8	(4.2)	192	(2.0)
Total	7,916	(81.5)	475	(4.9)	224	(2.3)	1,093	(11.3)	9,708	(100)

Numbers in ( ) indicate percentages.
Source: Traffic Management Group, Philippine National Police (2000)

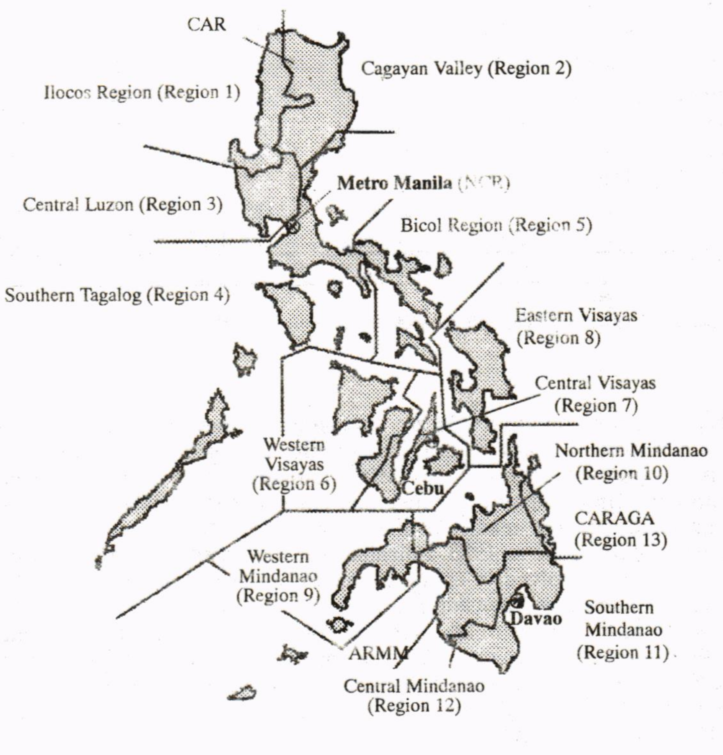

Figure 1. Regional map

Pertaining to type of vehicles (Table 3), automobiles form the majority of road traffic accidents in 1999 with a 40 percent overall share, followed by jeepneys with 20 percent, buses with around 17 percent, and trucks with almost 13 percent. In Metro Manila (NCR) where the rate of motorization is the highest, automobiles were involved in more than half of the accidents (52%) followed by bus (31%) and trucks (9%). Although the share of truck accidents ranks only third in Metro Manila, other regions such as Region 5 and Region 10 identify trucks as the principal transport mode involved in an accident. In addition, regions adjacent to Metro Manila such as Region 3 and Region 4 show that the incidence of accidents involving trucks is significantly higher than other modes with the exception of the automobile (and jeepney in Region 4). Further investigation of the PNP data reveals that a considerable amount of accidents in these regions occurred at National roads and at North and South Expressways connecting to Metro Manila.

Table 3. Road accidents according to vehicle type by region (1999)

Region	Bus	Truck	Auto	Jeepney	Motorcycle	Tricycle	Total
NCR	1,737 (31.2)	522 (9.4)	2,879 (51.6)	372 (6.7)	30 (0.5)	36 (0.6)	5,576 (39.5)
Region 1	9 (10.8)	17 (20.5)	22 (26.5)	17 (20.5)	7 (8.4)	11 (13.3)	83 (0.6)
Region 2	9 (11.0)	11 (13.4)	17 (20.7)	16 (19.5)	17 (20.7)	12 (14.6)	82 (0.6)
Region 3	38 (9.2)	90 (21.8)	115 (27.9)	84 (20.4)	32 (7.8)	53 (12.9)	412 (2.9)
Region 4	101 (8.9)	231 (20.3)	391 (34.4)	277 (24.4)	77 (6.8)	60 (5.3)	1,137 (8.1)
Region 5	42 (15.7)	59 (22.1)	47 (17.6)	58 (21.7)	31 (11.6)	30 (11.2)	267 (1.9)
Region 6	53 (9.7)	107 (19.5)	107 (19.5)	133 (24.2)	78 (14.2)	71 (12.9)	549 (3.9)
Region 7	65 (3.4)	119 (6.3)	609 (32.2)	864 (45.6)	175 (9.2)	62 (3.3)	1,894 (13.4)
Region 8	16 (15.4)	9 (8.7)	12 (11.5)	38 (36.5)	18 (17.3)	11 (10.6)	104 (0.7)
Region 9	14 (1.9)	60 (8.0)	344 (45.6)	249 (33.0)	82 (10.9)	5 (0.7)	754 (5.3)
Region 10	24 (8.5)	92 (32.7)	48 (17.1)	66 (23.5)	48 (17.1)	3 (1.1)	281 (2.0)
Region 11	141 (6.5)	340 (15.7)	929 (42.8)	519 (23.9)	139 (6.4)	102 (4.7)	2,170 (15.4)
Region 12	32 (10.6)	34 (11.3)	40 (13.3)	62 (20.6)	84 (27.9)	49 (16.3)	301 (2.1)
Region 13	30 (10.2)	39 (13.3)	84 (28.7)	54 (18.4)	43 (14.7)	43 (14.7)	293 (2.1)
CAR	13 (22.0)	5 (8.5)	27 (45.8)	11 (18.6)	1 (1.7)	2 (3.4)	59 (0.4)
ARMM	32 (20.0)	27 (16.9)	21 (13.1)	42 (26.3)	17 (10.6)	21 (13.1)	160 (1.1)
Total	2,356 (16.7)	1,762 (12.5)	5,692 (40.3)	2,862 (20.3)	879 (6.2)	571 (4.0)	14,122 (100.0)

Numbers in ( ) indicate percentages.
Source: Traffic Management Group, Philippine National Police (2000)

Although accidents involving trucks are comparatively rare, they tend to be more serious. In any collision between a truck and an automobile, the occupants of the automobile are at a greater risk of serious injury and death. Minor damage to a truck can cause enormous damage to an automobile. Unfortunately, accurate and comprehensive data that can support this claim on truck accidents are not readily available in Metro Manila, let alone in the Philippines. Nevertheless, a study done in 1983 indicated that for a sample of accident statistics in Metro Manila, trucks were involved in about 26 percent of fatal accidents (MMUTSRAPP, 1984). This amount is significant considering that trucks represent less than 10 percent of the vehicles on the road. Heavy freight vehicles are indeed involved in a higher proportion of fatal accidents than other vehicles, even though they are underrepresented in all road traffic accidents. Further research is needed to examine the extent and severity of truck involvement in accidents by directly analyzing primary sources of accident data such as the Traffic Accident Investigation Report (TAIR).

3. FACTORS THAT AFFECT SAFETY IN THE TRUCKING INDUSTRY

3.1 Literature Review

Several studies have tried to explain the factors involved in truck-related accidents. Explanatory variables include individual driver characteristics such as age, occupational experience, hours of service, and fatigue, among others. Other significant variables relate to operational characteristics such as low pay rates, size and type of firm, irregular route schedules, truck configuration, and nighttime driving. Since human error is cited more often than mechanical defects in truck-related accidents, there is a need to examine variables such as and similar to the aforementioned.

Driver error caused by fatigue is perhaps the most obvious safety risk in the trucking industry. Fatigue results in a decreased ability to maintain functionality due to mental or physical stress. As identified by the Fatigue Countermeasures Group, sleep loss and circadian rhythm disruption are the two major physiological phenomena that cause fatigue. Sleep loss describes the phenomenon of getting less sleep than needed for maximum performance and alertness. Losing a couple of hours of sleep can result in negative effects including degraded judgment, lack of concentration, and slowed reaction time, among others. The circadian rhythm, on the other hand, is the human body's internal clock that governs how the body functions on a daily basis. Any attempt to change the circadian rhythm can alter the way organs function, and disrupt human physiology and behavior resulting in severe damage to the body. Fatigue is the discernible effect of this damage. Fatigue is a normal response to many conditions common to trucking operations because of sleep loss, shift schedule, and long work cycles.

A study by the National Transportation Safety Board (NTSB, 1990) in the U.S. found that the most frequently cited probable cause of heavy truck accidents that were fatal to the truck driver was fatigue (31%), followed by alcohol and drug use impairment (29%). In 1995, the Board released the findings of its study on truck driver fatigue and concluded that the most critical factors in predicting fatigue-related accidents were the duration of the most recent sleep, the amount of sleep in the past 24 hours, and whether the sleep was split into shorter periods of time rather than one long period of time. Further analysis of 1993 Fatal Accident Reporting System (FARS) data indicated that truck driver fatigue was a contributing factor in as many as 30 to 40 percent of all heavy truck accidents (NTSB, 1995). In a study of driver fatigue in Australia, Haworth, et al. (1989) estimated that fatigue was a contributing factor to between 9 and 20 percent of fatal accidents involving trucks.

In 1996, the Federal Highway Administration (FHWA) released the results of a 7-year comprehensive commercial vehicle driver fatigue and alertness study (FHWA, 1996). Among the major findings of the report were: 1) time of day had more impact on driver fatigue and alertness than cumulative time on duty, with drowsiness more likely to occur when driving during the night than during daytime, and 2) drivers in the study did not get enough sleep and were not very good at assessing their own levels of alertness as manifested by their tendency to rate themselves as more alert than the performance tests indicated.

Disaggregate models of motor carrier accidents developed by Kaneko and Jovanis (1992) considered the driver's age and occupational experience, the number of hours off-duty prior to the last trip, and the number of hours driven in the last trip. They concluded that although driver age and the number of hours off-duty prior to a trip did not appear to be significant factors affecting accident rates, driver experience and the number of consecutive hours driven were significant. The highest risk groups were associated with drivers with less than five years of truck driving experience and drivers who had driven a truck continuously for nine hours or more.

Moses and Savage (1994) investigated the relationship between accidents and trucking firm characteristics such as size, ownership and type of cargo carried. They concluded that truck accident rates decline as firm size increases indicating that larger firms have superior safety performance than smaller firms. Based on their estimates, larger firms have about 50 percent lower accident rates than smaller firms. With respect to ownership, the study found that private carriers, or those carriers primarily involved in moving the products of their parent company, have accident rates 20 percent lower than for-hire carriers. The report further revealed that among the for-hire carriers, trucks carrying general commodities have accident rates 10 percent higher than trucks carrying specialized cargoes. Accident rates involving fatalities and serious injuries are 20 percent higher for carriers of hazardous materials than other carriers.

The type of carriage the truck driver is involved with, either short-distance delivery (short haul) or long-distance transport (line haul), may also affect accident rates. Short haul drivers are assigned short turnarounds to deliver a shipment to a nearby city, pick up cargo, and drive it back to their home base the same day. Long haul truck drivers, on the other hand, haul loads from city to city for a week or more before returning home. These truck drivers spend most of their working time behind the wheel but may also load or unload their cargo after arriving at the final destination. Since drivers on long runs may face boredom, loneliness, and fatigue, they are thought to face greater risks than short haul drivers.

3.2 The Metro Manila Truck Ban

There are no known studies whether the existing truck ban in Metro Manila has a significant effect on safety. A recent study by Punzalan (2000) tried to investigate the socio-economic impacts of the truck ban from the viewpoint of truck operators and drivers, as well as on truck operations. The study found that the truck ban has significant effects on trip-making routes and work schedules which resulted in increased practice of nighttime deliveries. This has considerably reduced the sleeping hours of operators and drivers and undesirably affected their personal and family activities. This result has significant implications on safety as well, as fatigue owing to sleep deficiency can negatively affect truck drivers' performance and alertness. This paper will be an attempt to evaluate the truck ban from the viewpoint of safety.

The truck ban ordinance of Metro Manila is a directive prohibiting freight vehicles from traveling along major roads within the metropolis during peak hours. It was initially implemented in 1978 to alleviate the effects of traffic congestion and to eliminate broken-down trucks from major roads. The original truck ban prohibits cargo trucks with a gross vehicle weight of more than 4 tons from using eleven major roads from 6:00 to 9:00 A.M. and 4:00 to 8:00 P.M. during the weekdays. The present truck ban, which is the result of several amendments, is categorized into two types: 1) peak-hour truck ban at ten major routes from 6:00 to 9:00 A.M. and from 5:00 to 9:00 P.M. everyday except Sundays and holidays, and 2) all-day truck ban along Epifanio delos Santos Avenue (EDSA), the city's major thoroughfare, from 6:00 A.M. to 9:00 P.M. everyday except Sundays and holidays. The truck's gross vehicle weight was also raised from 4 tons to 4.5 tons. This means that light container vans carrying cargoes are exempted from the truck ban. There is an ongoing debate on whether the truck ban, in actuality, has beneficial effects. However, there has been no comprehensive attempt to study the effects of the truck ban mainly because of the unavailability of accurate data on freight volumes and truck operations. Nevertheless, the National Economic and Development Authority in 1981 tried to evaluate the economic effects of the truck ban and concluded in their report that "economic losses due to the truck ban are indeed substantial". It further recommended the "immediate lifting of the ban to stave off further losses, not only to truck owners but to the economy as a whole" (NEDA, 1981). However, some technical reports questioned the accuracy of the study as it did not consider the benefits of reduced traffic and relied on data and methodology which were quite suspect.

4. DRIVER INTERVIEW SURVEY DATA

4.1 Descriptive statistics

To assess significant factors of safety in the trucking industry of Metro Manila, the study utilized data from a truck driver interview survey conducted by the National Center for

Transportation Studies of the University of the Philippines in 1999. The survey was actually carried out as part of a research on the impacts of the existing truck ban in the trucking industry of Metro Manila (Punzalan, 2000).

The survey used random sampling procedure in which interviewers selected truck drivers stationed at the terminals of the North and South Harbors and the Manila International Container Terminal (MICT) at random. One hundred eighty-four samples were collected in which five samples were excluded due to incomplete answers, thereby resulting in 179 samples used for analysis. The survey collected information on: a) respondents' characteristics such as marriage status, household, and education; b) respondents' work history and job characteristics such as truck driving experience, type of firm, employment status, type of vehicle driven, income, type of compensation; c) driving behavior such as time spent working and resting, amount of sleep obtained, accident in the last 12 months; d) perception about the most common causes of accidents; and e) drivers' attitudes toward the truck ban. The data is perhaps the most comprehensive collection of truck driver's individual and operational characteristics in Metro Manila.

Descriptive statistics of the factors hypothesized to have a significant effect on safety were generated by relating it to whether the truck driver reported having been involved in an accident in the last 12 months before the interview. This is a binary variable that take a value of one if the respondent replied in the affirmative and zero otherwise. Basic descriptive statistics on the sample of truck drivers are presented in Table 4. "All samples" refers to the 179 total data samples while "accident samples" refers to the data samples in which the respondent was involved in an accident in the last 12 months.

Table 4. Descriptive statistics on the sample of drivers

	All Samples (n = 179)	Accident Samples (n = 70)
	Mean (or Percentage)	Mean (or Percentage)
Driver characteristics		
Age	35.7 years (std. dev. = 9.35)	36.2 years (std. dev. = 9.59)
Truck driving experience	10.7 years (std. dev. = 7.49)	10.3 years (std. dev. = 8.62)
Income per month	8,006 (std. dev. = 2,333)	7,671 (std. dev. = 2,104)
Hours-of-sleep	4.8 hours (std. dev. = 1.77)	4.4 hours (std. dev. = 1.58)
Less than high-school education	27.4%	30.0%
High-school graduate	67.6%	61.4%
Some or all of college	5.0%	8.6%
Married	79.3%	74.3%
Operational characteristics		
For-hire firm	93.8%	95.7%
Trailer-truck	44.1%	52.9%
Trip frequency per week	5.8 trips (std. dev. = 1.93)	5.7 trips (std. dev. = 1.95)
Knowledge of truck ban ordinance	63.1%	55.7%
Night-time driving	93.3%	97.1%
Use of banned routes	22.9%	34.3%
Accident in last 12 months	39.1%	

4.2 Driver characteristics

The general relationship between age and accidents follows a U-shaped curve. Young drivers are likely to be involved in accidents as they are still in the process of improving their driving skills. Accident rates then go down as mature drivers achieve driving competence. Subsequently, accident rates rise again for older drivers as information processing capabilities decrease and motor skill responses decline due to the natural aging process. The collected data samples, however, are not adequate enough to substantiate this trend. Nevertheless, a comparison of the mean ages of the two sample types in Table 4 indicates that the mean age of drivers for "accident samples" is relatively higher than "all samples" signifying that increase in age increases the likelihood of a driver to be involved in an accident.

Experience in truck driving is associated with a higher level of truck safety. As indicated in Table 4, the average truck driving experience for "accident samples" is lower than the average truck driving experience for "all samples", implying that drivers with less occupational experience are more likely to be involved in an accident. Table 5a shows the percentage of accidents according to the number of years of occupational experience. Drivers with less than 6 years experience reported the highest percentage of accidents with around 43 percent. The accident rate declines as the drivers gain experience as shown by 34 percent for drivers with 6 to 10 years of experience, 11 percent for those with 11 to 20 years experience, and 10 percent for those with 21 to 30 years experience.

Drivers receiving higher salaries tend to drive safer than drivers with lower salaries. A check of Table 4 indicates that drivers who were involved in accidents have an average income of 7,671 pesos a month while drivers in all samples receive an average of 8,006 pesos a month. Table 5b confirms this result and shows that the percentage of accidents decreases as income increases. Truck drivers receiving less than 7,000 pesos a month reported a higher percentage of accidents at around 39 percent, followed by drivers receiving 7,000 to 8,999 pesos a month at 34 percent, and so on. Low wages can be a determinant of safety, as drivers who are not paid a sufficient wage may have to work an additional job to make ends meet. This puts enormous strain on drivers and encourages them to violate current rules on maximum working hours. It is assumed that as income increases, the likelihood of accidents decreases.

Numerous studies have confirmed that the average person needs about 8 hours of sleep to sustain alertness. Table 4 indicates that drivers who had an accident in the last 12 months spent an average of just 4.4 hours of sleep while the average sleep for all interviewed drivers is only 4.8 hours. This result supports the impression that most truck drivers are chronically sleep-deprived and functioning below the level of optimum alertness. The percentage of accidents generally decreases as the amount of sleep obtained increases. Table 5c shows that truck drivers who spent less than 3 hours of sleep reported 44 percent of accidents. Drivers who had 3.1 to 5 hours sleep also reported 44 percent while those who had 5.1 to 7 hours of sleep reported around 10 percent. It is expected that increases in the amount of sleep will decrease the probability of accidents.

Table 5. Accident statistics by experience, income and hours of sleep

a)

Experience	Percent
< 6 yrs	42.86
6 - 10 yrs	34.28
11 - 20 yrs	11.43
21 - 30 yrs	10.0
≥ 31 yrs	1.43

b)

Income/mo.	Percent
< 7000	38.57
7000 - 8999	34.29
9000-10999	17.14
11000-12999	7.14
≥ 13000	2.86

c)

Sleep	Percent
< 3 hrs	44.29
3.1 - 5 hrs	44.29
5.1 - 7 hrs	9.99
7.1 - 9 hrs	1.43
≥ 9 hrs	0

The relationship between education and the likelihood of accident apparently contradicts conventional belief as revealed in Table 4. Looking at the variables relating to education (i.e. less than high school, high-school graduate, and college) and comparing their percentages for the two sample types, it can be observed that drivers who completed some or all of college were proportionately more involved in an accident in the last 12 months thereby contradicting the popular impression that educational attainment results in increased safety (5% for all samples vs. 8.6% for accident samples). As expected, the proportion of accidents increases for drivers who have not completed high-school education (27.4% for all samples vs. 30.0% for accident samples). In contrast, the proportion of accidents for truck drivers who finished high school decreases from 67.6 percent for all samples to 61.4 percent for the accident samples.

These results suggest that exceptional educational attainment is not a precondition to safe driving. As the driving profession relies more on manual skill rather than intellectual capability, many trucking companies are not very strict about educational attainment as long as the driver can prove his ability to safely handle and operate large vehicles. In general, truck drivers must have at least finished high school, and must be able to read and speak well enough to read road signs, prepare simple reports, and communicate with law enforcement officers and the public.

4.3 Operational characteristics

Truck operators or for-hire trucking companies employ the majority (93%) of the interviewed drivers. This is expected considering that the survey was done inside the port area. This percentage further increases to almost 96 percent upon examination of the sample of drivers involved in an accident. Thus, it is hypothesized that drivers working for a for-hire firm are more likely to be involved in accidents than private carriers. The presumption is that private carriers place more emphasis on safe operation since it is the company's own cargo that would be damaged in case of an accident. Another advantage of private carriers is that they have relatively repetitious operations implying that drivers are more familiar with specific routes and local conditions.

Fifty-three percent of truck drivers with involvement in an accident in the last 12 months operate trailer-trucks. Articulated and trailer-type trucks apparently present greater hazards than rigid or single-unit trucks. Geometric characteristics of roads often limit maneuverability and visibility of trailer-type trucks, thereby increasing the risk of an accident. Increased aborted passing maneuvers of automobiles are also anticipated because of the longer dimension of trailer-trucks. Truck accident statistics in France reveals that trailer-type commercial vehicles were involved in more serious accidents than single-unit trucks (OECD, 1992). In the U.S., studies in North Carolina have shown that large tractor-trailer trucks had higher fatal accident involvement rates than single-unit trucks between 1995 and 1999 (Hughes, *et al*., 2000). Angle crashes represented the highest probability of an accident, while the share of overturning trucks was between 12 to 15 percent of fatal crashes. Overturns are frequent as a consequence of the poor lateral stability of trailer-type trucks. It is predicted that drivers using trailer-type trucks have a greater risk of being involved in an accident.

Knowledge on the truck ban serves as a proxy on how well truck drivers are informed of existing traffic rules and regulations. As mentioned in the previous sections, driver error is the primary cause of accidents, and that a major portion of it is due to negligence of some basic traffic rules and regulations. The survey revealed that 63 percent of the interviewed drivers were well informed of the truck-banned routes and their corresponding schedules. In contrast, only 56 percent of the drivers involved in an accident in the last 12 months were able to state the truck ban schedule correctly. It is assumed that drivers familiar with the truck ban ordinance are less likely to have accidents.

Nighttime driving increases the risk of a fall-asleep accident. Truck drivers who work at night also face greater risk because they are disrupting their body's natural time clock or circadian rhythm. Another factor related to nighttime driving is the poor visibility of trucks at night. An OECD study reveals that one of the main causes of nighttime accidents is the poor perception of trucks by motorists (OECD, 1992). Majority or around 93 percent of truck drivers perform nighttime deliveries to avoid the adverse effects of the truck ban. Ninety-seven percent of the drivers reported involvement in an accident in the last 12 months.

There are drivers who risk using the banned routes to speed up transport operation of goods with strict delivery schedules in the hope that they will not be apprehended by a police officer, or, if apprehended, they can easily "pay their way out" by bribing the police officer not to issue any violation. This practice is prevalent as law enforcement in Metro Manila is relatively lenient. As shown in Table 4, approximately two out of ten drivers interviewed will risk using the truck-banned routes when faced with a rush delivery. The ratio increases to three out of ten for drivers who were involved in an accident in the last 12 months. Thus, the probability of accidents increases for drivers who use the banned routes during the truck ban period.

5. THE ANALYTICAL MODEL

5.1 Probit Model

The data presented in Tables 4 and 5 provide preliminary findings of how variables will affect the likelihood of accidents. It is difficult, however, to discern from these bivariate statistics the relative importance of driver and operational characteristics in determining the occurrence of an accident. A multivariate statistical model is employed to explore their relationship.

The dependent variable, accident, is represented by a dummy variable where a respondent involved in an accident in the last 12 months is coded as 1, and 0 otherwise. The driver's individual and operational characteristics, represented by a vector **x**, serve as independent or explanatory variables. Hence, a regression relationship can be defined as:

$$Y^* = \boldsymbol{\beta}'\mathbf{x} + \in \quad (1)$$

where $\boldsymbol{\beta}'$ is a vector of parameter coefficients to be estimated, $\in$ is a disturbance term, and Y^* is an unobserved response variable represented by the observed dummy variable on accident, Y, defined as:

$$\begin{aligned} Y &= 1 \quad \text{if } Y^* > 0 \\ Y &= 0 \quad \text{otherwise} \end{aligned} \quad (2)$$

Assuming that the disturbance term, $\in$, is normally distributed across observations and the mean and variance are normalized to zero and one, respectively, the Probit model is used to estimate the above relationship in the general framework of probability models:

$$\begin{aligned} \text{Prob}\,(Y = 1) &= \int_{-\infty}^{\boldsymbol{\beta}'\mathbf{x}} \phi(t)\,dt \\ &= \Phi(\boldsymbol{\beta}'\mathbf{x}) \end{aligned} \quad (3)$$

where $\Phi(\ )$ is the cumulative distribution function, and $\phi(t)$ is the density function of the standard normal given by:

$$\phi(t) = \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{1}{2}t^2\right) \quad (4)$$

The choice of a probit model over the logit model is arbitrary. Because the cumulative normal distribution and the logistic distribution differ very little, and only at the tails, the empirical results obtained from the two models will be very close, unless the sample size is very large (Maddala, 1983, Greene, 2000). This does not apply to our data set.

Since the probit model does not take on a linear form, the estimated coefficients, $\boldsymbol{\beta}'$, are not accurate estimations of the effects of the independent variables on the probability. The marginal effects are thus computed. The marginal effect of a particular variable reports the change in probability of the dependent variable following a unit change in the independent variable, or, in the case of dummy variables, a switch from 0 to 1, while holding other variables constant. Thus, the marginal effects are simply the derivatives of the probit function with respect to a particular explanatory variable. Hence,

$$\frac{\partial}{\partial \mathbf{x}} \Phi(\boldsymbol{\beta}'\mathbf{x}) = \phi\,(\boldsymbol{\beta}'\mathbf{x})\,\boldsymbol{\beta} \tag{5}$$

Marginal effects are usually evaluated at the means of the explanatory variables.

5.2 Identification of variables

The explanatory variables in the estimation include driver characteristics, operational characteristics, and perceptions on the existing truck ban. Table 6 defines the variables, as well as the expected signs for the coefficients indicating whether the variable will cause an increase or decrease in the likelihood of accidents. A positive sign on a continuous variable such as age, truck driving experience, and income, among others, implies that the likelihood of accident increases as the value of the specific variable increases by one unit. Similarly, a positive sign for a dummy variable such as married, for-hire firm, trailer truck, etc., indicates that the likelihood of accident increases as the dummy variable takes on a value of one.

In the model, experience (EXPER) is included and age is omitted because of the high correlation between the two variables. It is expected that the sign for EXPER will be negative implying that more experienced drivers are less likely to have an accident. Marital status (MARRIED) is included to differentiate married and single drivers. It is believed that married drivers will drive safer presumably because they will be more careful given that they have dependents or a family to consider. The expected sign on MARRIED is negative implying that being married decreases the probability of accidents. Education is included to enable us to test how different levels of education affects the likelihood of accidents. Educational attainment is coded as two binary variables, less than high school (NO_HS) and some or all of college (COLLEGE), with the high school graduate being the excluded category. A positive sign is expected for both variables.

Dummy variables for the type of firm and truck configuration are included and represented by FOR_HIRE and TRAILER, respectively. It is expected that the variable FOR_HIRE will have a positive sign, implying that drivers working for a for-hire firm are more likely to be involved in accidents than private carriers. Likewise, the sign for the truck-trailer variable is expected to be positive implying that drivers using trailer-trucks have a greater risk of being involved in an accident.

A continuous variable for INCOME is included to allow for possible financial effects on accidents. This variable is a proxy for driver wage rates. A negative sign is expected implying that as income increases, the likelihood of accident decreases. To consider the effects of fatigue, a continuous variable on hours-of-sleep (SLEEP) is included. The expected negative sign on SLEEP indicates that increases in the amount of sleep decreases the occurrence of accidents.

Dummy variables that relate to the truck ban are: knowledge of truck ban (BAN_KNOW), nighttime deliveries (NT_DRIVE), and use of banned routes during rush delivery (BAN_USE). The expected sign for the BAN_KNOW variable is negative implying that drivers familiar with existing traffic rules and regulations like the truck ban ordinance are less likely to have accidents. On the other hand, the expected positive sign on NT_DRIVE variable indicates that the likelihood of accident increases when the driver performs nighttime driving. Finally, a positive sign is expected for BAN_USE indicating that the probability of accidents increases for drivers who use the banned routes during the truck ban period.

Table 6. Variables used in the estimation

Dependent variable	Measurement	
Accident, *Y*	1 = accident in the last 12 months 0 = otherwise	
Independent variables	**Measurement**	**Expected Sign**
Experience and marital status		
Job Experience, EXPER	years	-
Marital Status, MARRIED	1 if married, 0 otherwise	-
Education		
NO_HS	1 if less than high school education, 0 otherwise	+
COLLEGE	1 if some or all of college, 0 otherwise	+
Type of firm		
FOR_HIRE	1 if driving for a for-hire firm, 0 otherwise	+
Truck configuration		
TRAILER	1 if driving a trailer-type truck, 0 otherwise	+
Income and sleep hours		
Income per month, INCOME	pesos	-
Hours of sleep, SLEEP	hours	-
Truck ban issues		
BAN_KNOW	1 if driver understands truck ban ordinance, 0 otherwise	-
NT_DRIVE	1 if driver performs nighttime driving, 0 otherwise	+
BAN_USE	1 if driver violates truck ban during rush delivery, 0 otherwise	+

6. RESULTS OF PROBIT ESTIMATION

Table 7 presents the probit estimation results for the hypothesized accident model. The estimated binary probit model is significant as manifested by the likelihood ratio statistic of 31.01 which is well above the 95 percent critical value from the chi-squared distribution with 11 degrees of freedom set at 19.68. Thus, the null hypothesis that the coefficients of the explanatory variables are zero is rejected. Furthermore, majority of the signs on the marginal effects are consistent with the theoretical predictions. Significant explanatory variables at the 5% and 10% level for a two-tailed test are COLLEGE, TRAILER, SLEEP, BAN_KNOW, NT_DRIVE, and BAN_USE.

Table 7. Probit marginal effects

Variable	Coefficient	t-stat	P-value
Constant	-0.068919	-0.207	0.8364
EXPER	-0.001855	-0.340	0.7341
MARRIED	-0.077362	-0.780	0.4352
NO_HS	0.127864	1.437	0.1507
COLLEGE	0.337596*	1.842	0.0654
FOR_HIRE	-0.028910	-0.157	0.8752
TRAILER	0.187612**	2.266	0.0235
INCOME	-0.000019	-1.063	0.2880
SLEEP	-0.046930**	-2.062	0.0392
BAN_KNOW	-0.150257*	-1.824	0.0682
NT_DRIVE	0.357105*	1.836	0.0663
BAN_USE	0.254487**	2.723	0.0065
Number of observations		179	
Degrees of Freedom		11	
Likelihood Ratio Test Statistic		31.01	

* Significant at 10% level
** Significant at 5% level

Being married (MARRIED), although statistically insignificant, decreases the probability of accidents as shown by a negative sign. The same effect is revealed by the coefficients on experience (EXPER) and income (INCOME), supporting the assumptions made a priori. Job experience and income are also not significant influential variables of accident occurrence. Likewise, the regression results show that the type of trucking firm (FOR_HIRE) is not significantly related to the occurrence of accidents.

Higher educational attainment has a significant positive relationship with accidents. The 0.337 coefficient on COLLEGE indicates that drivers who had attended and/or finished college are 33.7 percent more likely to have an accident than those with a high school degree. Likewise, drivers with no high-school degrees (NO_HS) have a positive effect, although statistically insignificant, on the likelihood of accidents. These results support the previous assumptions made.

Also, the coefficient for drivers operating a trailer truck (TRAILER) is positive and statistically significant. These drivers are 18.7 percent more likely to be involved in an accident than non-trailer truck drivers, all else held constant.

As expected, the coefficient on sleep (SLEEP) significantly affects the likelihood of accidents negatively. Drivers who sleep more are less likely to be involved in accidents. The –0.0469 coefficient indicates that for every increased hour of sleep, a driver is almost 4.7 percent less likely to be involved in an accident.

The coefficients on the variables related to the truck ban are all statistically significant. The coefficient on knowledge of the truck ban variable (BAN_KNOW) is –0.15, indicating that drivers who are familiar with the truck ban ordinance are 15 percent less likely to have accidents than their counterparts unfamiliar with the regulation. On the other hand, drivers performing nighttime deliveries (NT_DEL) are 35.7 percent more likely to be involved in accidents than drivers working only during the day. Likewise, the coefficient for drivers violating the truck ban during rush deliveries (BAN_USE) has a positive effect on accidents. Violators of the truck ban are faced with a greater accident risk of 25.4 percent than drivers avoiding the banned routes.

7. CONCLUSION

This study has explored the determinants of safety in the trucking industry of Metro Manila. Detailed data of individual truck drivers, their operational characteristics, and attitudes on the existing truck ban were used in the analysis. Probit estimation results suggest that the likelihood of accidents increases when a driver operates a trailer-truck, has no complete knowledge of the truck ban ordinance, performs nighttime deliveries, violates truck ban rules, and has insufficient sleep. Marginal effects indicate that the probability of accident increases by almost 19 percent if a driver operates a trailer-truck. A driver unfamiliar with the truck ban ordinance is also 15 percent more likely to be involved in an accident, while a driver who performs nighttime deliveries has around 36 percent higher probability of having an accident than a driver who drives only during the day. Likewise, a driver using the banned routes during truck ban hours is 25 percent more likely to encounter an accident than a driver avoiding the truck-banned routes. Finally, the likelihood of accident decreases by 4.7 percent as the number of sleeping hours increases by an hour.

The results suggest that policies centered on education of the driver are likely to be effective in reducing truck accidents. Because driver error is the predominant causal factor of accidents, significant effort must be placed in eliminating or reducing driver errors or mitigating the effect of such errors. Driver education on the basic road signs and traffic rules and regulations such as the truck ban, and training of drivers to improve their skills can be major strategies to enhance truck drivers' safety performance. Policies on mandatory training before the issuance of truck driver licenses should be strictly exercised. Truck driver education may cover a range of programs ranging from teaching new drivers, to upgrading skills, to providing special training for special vehicles, and may consist of the following components: 1) classroom - where safe driving concepts and compliance with traffic signs and regulations are emphasized, 2) practicing range - where driving skills are polished before actual road exposure, and 3) on-the- road-driving - where drivers learn from actual traffic exposure on the road.

In addition, policies that focus on the effective management of nighttime deliveries can be considered crucial in improving safety. While it is not feasible to eliminate nighttime driving, there should be regulations that aim to restrict the driving hours of drivers working through the night, when fall-asleep crashes are more prevalent. It is encouraged that a rotation of drivers be done in such a way that nighttime driving and the associated accident risk is distributed among drivers.

Another important result of the study is the finding that the truck ban has a direct impact on the likelihood of accidents. This result suggests that policy makers should thoroughly review the effects of the truck ban and find ways to alleviate its negative impacts. Although it may be impossible to eliminate the existing truck ban at present, there should be guiding policies on the management of nighttime deliveries, and strict implementation of maximum working-hour rules to ascertain that truck drivers get the proper sleep they need. Truck drivers should be also given predictable schedules as often as possible so that they can properly plan for sufficient sleep and fulfill family obligations. This is especially important to drivers who work evening or night shifts when cumulative sleep deprivation could coincide with the disrupted circadian rhythm, thus increasing accident risk.

Finally, the lack of adequate data on the characteristics of large trucks involved in accidents inhibits further research. It is essential that a significant effort be made to obtain such data.

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REFERENCES

Econometric Software (1998) **LIMDEP Version 7.0.** Econometric Software Inc., New York.

Fatigue Countermeasures Group. http://olias.arc.nasa.gov/zteam/fredi/fatg.trans.html.

Federal Highway Administration (FHWA) (1996) Commercial motor vehicle driver fatigue and alertness study. FWHA-MC-97-001, Washington, DC.

Greene, W.H. (2000). **Econometric Analysis, 4th ed.** Prentice-Hall, New Jersey.

Haworth, N., Heffernan C. and Horne, E. (1989) Fatigue in truck accidents. Monash University Accident Research Center Report No. 3. http://www.general.monash.edu.au/muarc/rptsum/eso3.htm.

Hughes, R.G. and Rodgman, E. (2000) Commercial vehicle safety in North Carolina: An analysis of crash data for the period 1995-1999. Report prepared for the North Carolina Governor's Highway Safety Program.

Kaneko, T. and Jovanis, P. (1992) Multiday driving patterns and motor carrier accident risk: A disaggregate analysis. **Accident Analysis and Prevention 24, No. 5**, 437-456.

Maddala, G.S. (1983) **Limited Dependent and Qualitative Variables in Economics.** Cambridge University Press, Cambridge.

Mendoza, P. (forthcoming) Unpublished Ph.D. thesis on Filipino drivers' behavior and psychology, De La Salle University.

Metro Manila Urban Transportation Strategy Planning Project (MMUTSTRAP) (1984) Truck operations, Ministry of Transportation and Communications, Metro Manila.

Moses, L. and Savage, I. (1994) The effect of firm characteristics on truck accidents. **Accident Analysis and Prevention 26, No. 4**, 173-179.

National Economic and Development Authority (NEDA) (1981) The truck ban in Metro Manila's major thoroughfares: A policy analysis.

National Transportation Safety Board (NTSB) (1990) Fatigue, alcohol, other drugs, and medical factors in fatal-to-the-driver heavy truck crashes, Vol. 1, Washington, D.C.

National Transportation Safety Board (NTSB) (1995) Factors that affect fatigue in heavy truck accidents, Vol. 1, Washington, D.C.

OECD (1992) **Cargo routes: Truck roads and networks.** Road Transport Research, Paris.

Philippine Daily Inquirer (2000) Most traffic accidents due to driver's error, 21 September.

Punzalan, J. (2000) The impact of truck ban on the trucking industry in Metro Manila. Unpublished Master's Thesis, University of the Philippines.

Traffic Management Group, Philippine National Police records of road traffic accidents for 1998 and 1999.

U.S. Department of Transportation (1996) Transportation Expressions, Bureau of Transportation Statistics, Washington, D.C.