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道路運輸安全政策成效衡量之研究：酒後駕車防
治政策與國道客運市場解除管制政策

**Assessing the Safety Effects of Road Safety-Related Policies:
Preventing Drunk Driving and Deregulation of Intercity Bus
Industry**

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摘 要

本研究主要目的在處理二項關於道路運輸安全相關政策效果評估之主題，一項為衡量遏阻個體駕駛人之不當駕駛行為之肇事防治政策之時間效果，另一項為國道客運市場解除管制政策之安全衝擊評估。前者之研究主軸在於以生命週期理論為基礎，發展出衡量肇事防治政策之一般遏阻效果與其時間變異之方法。此一部份研究係以酒後駕車列入刑法公共危險罪政策在台北市之實施成效作為實例進行理論驗證工作。後者之研究主軸則以 Reason(1997) 提出之組織肇事理論為礎石，發展出一套可衡量解除管制政策對個別運輸公司安全績效影響之理論架構。

應用生命週期理論為基礎發展出描述肇事防治政策效果之可能變化型態之理論。配合使用因果關係分析技術 (Causal factor analysis techniques) 分別以虛擬變數和時間變數方法發展衡量酒後駕車列入刑法公共危險罪政策之平均效果與時間變異效果之模式。經模式校估結果顯示，以時間變數為基礎之模式優於虛擬變數為基礎之模式。在控制執法與酒類產品消費因子下，本研究獲致酒後駕車列入刑法公共危險罪政策執行二十個月內之時間效果變化狀態。本研究結果顯示安全干預政策之時間變異效果確實存在。此外，我們進一步探討使用不同觀察時間長度進行政策成效衡量所可能產生之謬誤。此部分之研究發現提供政策評估研究工作上非常寶貴之資訊，並對相關研究之分析者提出警告，必須謹慎地解釋其評估研究之結果，以免因誤解導致不適當的結論。同時，我們並建議政府應該在安全改善政策執行期間持續進行監視工作，而非經過一段相當時間後才進行評估工作。

本研究在第二部分以 Reason(1997)所提出之組織肇事理論作為基礎，發展出一理論架構以模化運輸公司之安全績效及其組織和環境因子間之關係。台灣地區國道客運市場解除管制政策之實施提供一個絕佳的機會以回應一項非常重要的研究議題：是否解除管制會對安全產生負面衝擊？此研究主題屬於一項橫斷面研究（Cross-section study），係透過比較加入提供國道客運服務之公司與未加入提供國道客運服務公司之安全表現來評估解除管制政策是否對安全產生負面效果。研究結果顯示在解除管制後成立的國道客運公司與其他之前已成立的客運公司間之安全績效並無顯著差異。但是提供國道客運服務者之公司無論新舊都比其他舊的未參加提供國道客運之公司具更高的肇事率。此係所有提供國道客運服務之公司在該項業務上幾乎都是新手所致。此外，公司組織因子與其他環境因子對於其安全績效具顯著影響。此研究成果不僅可以協助政府辨識哪些公司是屬於高肇事風險公司，並在設計更妥適之策略或安全管制措施上提供非常寶貴的資訊。最後，我們研擬適當的安全管制措施以有效提升客運公司安全績效。

**Assessing the Safety Effects of Road Safety-Related Policies:
Preventing Drunk Driving and Deregulation of Intercity Bus Industry**

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Abstract

This study aims to deal two related issues about measuring the safety effects of transport safety-related policies- the temporal effects of accident prevention policies focused on individual drivers' behaviors and the safety impacts of deregulation of intercity bus industry on individual bus companies. The former is essentially addressed on measuring the general deterrence of the policy and its temporal variation based on the life cycle theory. The implementation of criminal sanctions for drunk driving (CSFDD) in Taipei City is then taken as an empirical example to determine whether the time variability of the safety effect really existed for the CSFDD. The latter aims to determine the safety impacts of deregulation on individual transport companies based on Reason's organizational accident theory (1997). Causal factor analysis techniques are employed to investigate the issues.

Life cycle theory is applied to describe the potential changing patterns of the safety effects of the accident reduction policy. Causal factor analysis techniques with dummy-based and time-based specifications are developed to measure the average effects and temporal effects of the CSFDD policy. The time-based specification model was demonstrated to be better than the dummy-based specification model in evaluating the effect of safety policy on reducing the alcohol-related crashes here. Excluding the influences brought about by enforcement and alcohol consumption, the safety effect pattern over time for the CSFDD policy was explored in an observation

period of 20 months following its implementation. We found that there existed a temporal variation for the intervening policy. In addition, we explore the potential fallacies in measuring the safety effects of the policy with different observational periods. The findings of this chapter provide a set of valuable information for policy evaluation and alert the analysts to interpret their evaluation results carefully to avoid making an inappropriate conclusion. Also, we suggest that monitoring the effects of the policy along with its implementation time period may be more beneficial than evaluating the effect within some given observational time period.

Organizational accident theory proposed by Reason (1997) is applied to develop a framework relating the safety performance to organizational and environmental factors for a bus companies. Deregulation of intercity bus industry in Taiwan provides an opportunity to answer the important research issue concerning whether deregulation would bring negative impacts on safety performance. This issue is a cross-section study to determine whether deregulation has negative impacts on individual bus companies from a comparison of the safety performance of the bus companies with providing intercity bus services and those without providing intercity bus services. The results show that the new established bus companies in the era of deregulation have indifferent safety performance with other old bus companies. The novice operators in intercity bus services have experienced poor safety performance than those old bus companies without providing intercity bus services. The organizational factors and other environmental factor also appear significant effects on the safety performance of individual bus companies. The results not only provide authorities to identify which companies have higher accident risk, but also offer very valuable information to design more appropriate strategies or safety regulations on improving safety performance of bus companies. Finally, we suggest some safety

regulation policies be conducted in conjunction with the implementation of economic deregulation in order to pursue a better safety performance by the bus transport industry as a whole, rather than just prevent the deterioration of the existing safety performance.

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CHAPTER 1

Introduction

This study examines two related topics in measuring safety effects of transport safety-related policies: the safety effects of the accident prevention policy and the impacts of deregulation of intercity bus industry on safety performance of bus companies. The first topic is to apply life cycle theory to determine the temporal variation of the effect the accident prevention policy. In addition, the demonstration concerning the potential fallacies in measuring the effects of the accident prevention policy with different observational periods is presented in this study. The second topic aims to apply Reason's organizational accident theory (1997) to formulate the safety performance models of individual bus companies relating the safety performance to organizational and environmental factors. We will discuss motivations, objectives, approaches, overview and contributions of the research in detail in the following parts.

1.1 Research Motivations

Traffic accidents demand many lives and cause huge social cost every year. How to reduce accidents effectively is a main issue concerned by the public, authorities and researchers in many countries. Many interventions from enforcement, education, and engineering aspects have been developed and implemented to prevent the occurrence of accidents. Although every intervention is implemented with some safety objective, the intervention may be do more harm than good or ineffective (Evans, 1985). Because the resource available to improve safety is very limited, the resource devoted in the ineffective intervention could be put to other interventions. Thus, to determine whether one safety intervention is effective on accident reduction seems beneficial in

allocation of resources and road safety management.

Therefore, a lot of observational before-and-after studies have been conducted to try and measure their effects on reducing the accident rate (e.g. Rogers and Schoenig, 1994; Hauer, 1997; Voas et al., 2000). Basically, the safety effect of an intervention policy either comes out quickly following its implementation (e.g. pavement resurfacing), or appears gradually (e.g. safety education). In addition, once the safety effect appears, it may increase with time over some period to reach its maximum, and then sustain this maximum effect indefinitely or decline gradually. The effect of safety measures may vary over time due to changes in the enforcement efforts, the design of the measures, and changes in public attention or social norms over time. Thus, the temporal variation of the safety effect implies that each intervention policy may have its own unique evolution process within a different context. This means that researchers will face the problem of deciding when it is the appropriate time to measure the safety effect of a prevention policy after its implementation.

Most of relevant studies have been undertaken to measure the average effect of the policy or the compound effects of several influencing factors (Rogers and Schoenig, 1994; Hauer, 1997; Voas et al., 2000; Chang and Yeh, 2003ab). However, the temporal variation of the effect of the policy has not been measured quantitatively in past literature. The temporal variability may bias the results of the evaluation studies and lead to a misunderstanding of the safety effect of the policy. Thus, the first topic in this study is conducted to measure the temporal effect of the policy on reducing accidents. A new method based on life cycle theory is proposed to measure the temporal effect of the policy quantitatively with controlling other influencing factors.

The safety performance of transport companies is second topic addressed in this

study. The issue concerning whether deregulation of transportation has brought negative safety impacts is one of most frequent evaluated policies in organizational level. Although deregulation is an economic policy, the research issues concerning the safety impact of deregulation of different transport industries, including trucking, airlines, and bus, have been received much attention in literature (e.g. Chow, 1987; Capelle and Beilock, 1987; Jerome, 1985; Evans, 1994; White et al., 1995; White, 1995). Some studies found that no negative safety effects appeared on the whole industry (Chow, 1987; Capelle and Beilock, 1987; Jerome, 1985; Evans, 1994; White et al., 1995; White, 1995), but some found that deregulation might change the behaviors of truck companies, and affect their safety performance (Chow, 1989; Corsi and Fanara, 1989; Jovanis, 1989). The inconsistencies appeared between the impacts of deregulation on the safety performance of individual carriers and the transport industry as a whole.

Intercity bus transportation, which handles more than 60% of the intercity passenger trips in recent years, is the primary mode for long distance travel in Taiwan (MOTC, 2002). In Taiwan, under the pressure of rapid market expansion and worldwide enterprise privatization, the entry barrier to the intercity bus market was removed in 1995. Many new companies have joined the existing bus companies in this deregulated market. Deregulation has resulted in some positive effects on intercity transportation service, such as lower fares, more frequent service and new vehicles with luxurious entertainment facilities. However, deregulation has also brought the pressure of competition to bus companies. This could force bus companies to reduce resources previously allocated to safety management, and thereby posing a threat to their safety performance. Moreover, with deregulation, less experienced companies and drivers have entered the industry. A serious question that

has arisen from deregulation is: will the higher accident risk associated with the lack of experience of these novice companies will be offset by the implementation of new safety management concepts and new vehicles?

Deregulation of intercity bus industry in Taiwan provides an opportunity to explore the reasons why the inconsistencies existed in literature and determine the effects of deregulation, organizational and environmental factors on safety performance of individual bus companies.

1.2 Research Objectives

Since measuring the effects of road safety-related policies is an important research issue in road safety improvement, two road safety-related topics focused on deterring individual drivers' behaviors and safety performance of transport companies respectively are presented in this study. First topic addressed in this study aims to apply life cycle theory to formulate the model in measuring the temporal effects of the safety-related policy. The drunk driving prevention policy in Taiwan is taken as an empirical example. In addition, because the temporal variation of the effects of the policies may mislead the interpretation of the results, the issue concerning the potential fallacies in measuring the effect of the policy with different observational periods is presented and demonstrated by the same example. Second topic in this study is undertaken to explore the safety impacts of deregulation of intercity bus industry, and provide some policy implications to improve the safety performance of bus companies. The framework based on Reason's organizational accident theory (1997) is developed to relate the organizational and environmental factors to the safety performance of individual bus company. The deregulation of intercity bus industry in Taiwan is taken as an empirical example to provide valuable knowledge

concerning the safety impacts of deregulation, organizational factors and environmental factors on safety performance of individual bus companies. The objectives of second part of this study are not only to explore whether the deregulation brought some negative impacts on safety performance, but also to find out some policy implications for improving safety performance of individual bus companies.

Consequently, the main objectives of this dissertation are as follows:

- (1) Applying life cycle theory to describe the potential changing patterns of the effect of the safety policy.
- (2) Modeling the temporal effects of the safety policy based on the life cycle theory.
- (3) Presenting a detail comparison and discussion for the potential fallacies in measuring the effects of the safety policy with different observational periods.
- (4) Developing a framework to formulate the safety performance models of individual bus companies by applying Reason's organizational accident theory.
- (5) Modeling the relationships between the safety performance and organizational and environmental factors. Thus, the models could be used to measure the safety impacts of deregulation. Furthermore, some policy recommendations may be derived from the findings of the research to improve the safety performance of the bus industry.

1.3 Research Approach

In order to measure the safety effects of the two kinds of transport safety policies, this study tries to develop two different frameworks based on life cycle theory and Reason's organizational accident theory (1997) respectively. Life cycle theory is used

to describe the changing pattern of the safety effects of the intervention in first topic. Then, causal factor analysis techniques with dummy-based and time-based specifications are developed to measure the changing safety effects of the intervention along with its implementation time period with controlling the other influencing factors. The implementation of criminal sanctions for drunk driving (CSFDD) in Taipei City is then taken as an empirical example. In addition, the other important issue about measuring the effects of the intervention with different observational time period may arise from the existence of temporal variation of the effect. Therefore, we demonstrate that the potential fallacies in measuring effects of the intervention with different observational time periods by using pair-t tests, causal factor analysis techniques with dummy based specifications, and causal factor analysis techniques with time-based specifications.

In second topic of this study, Reason's organizational accident theory (1997) is applied to develop a framework describing the safety performance is determined by organizational and environmental factors in order to determine the impact of deregulation on individual bus companies. Deregulation of intercity bus industry in Taiwan has been taken as an empirical example. Causal factor analysis techniques are employed to formulate the safety performance models of individual bus companies based on the framework proposed in this study.

1.4 Overview of Thesis

This thesis is organized as follows. Chapter 2 presents a brief literature review regarding the evaluation studies of road safety measures. Chapter 3 presents how to measure the effect of the drunk driving prevention policy using the life cycle theory, and Chapter 4 addresses the potential fallacies in measuring the effects of accident

prevention policies with different observational periods. Chapter 5 proposes a framework to formulate the safety performance models of individual bus companies relating accident rates to organizational and environmental factors based on Reason's organizational accident theory (1997). Chapter 6 summarizes and concludes this study.

1.5 Research Contributions

The main contributions of this study are summarized as follows:

- (1) Applying life cycle theory to describe the evolution process of the effect of an accident prevention policy during its implementation period.
- (2) Development of a method based on causal factor analysis techniques to measure the temporal variation of the effect quantitatively.
- (3) Demonstration and discussion the issue regarding the potential fallacies in measuring the effects of accident prevention policies with different observational periods.
- (4) Development of an integrated framework to formulate safety performance models of individual bus companies. The models relate the safety performance to organizational and environmental factors in order to provide the answers for the important research issues in relevant literature: Has deregulation policy affected the safety performance of bus industry? Had deregulation policy influenced each individual bus operator's behavior and safety performance?
- (5) Assessment of the effects of the organizational an environmental factors on the safety performance of individual bus companies. The policy

recommendations based on the results are proposed to improve the safety performance of bus companies.

CHAPTER 2

Literature Review

This chapter presents a short literature review on measuring the effects of safety intervention in road safety, and relevant studies concerning the safety impacts of deregulation.

2.1 The evaluation of accident prevention measures in literature

Most of the safety measures evaluation studies could be divided into two types, including macro-level and micro-level. The macro level is that the studies evaluate the effects of safety measures in deterring some types of risky behaviors, such as drunk driving, speeding, and etc, in aggregate level, while the micro level implies that the studies evaluate the effect of safety measures in deterring some risky behaviors in individual level. In addition, the safety measures may have two kinds of effects (Rogers and Schoenig, 1994; DeYoung, 1999, 2000), including specific deterrent effects and general deterrent effects. The specific deterrence of a safety measure is defined that the effect among the some types of offenders who experience the punitive effects of the new laws (Rogers and Schoenig, 1994, DeYoung, 1999; McArthur and Kraus, 1999). The general deterrence implies that the new laws or measures would cause a general deterrent effect among the potential offenders who would be deterred from violation by the mere threat of the new law's punitive nature (Rogers and Schoenig, 1994; McArthur and Kraus, 1999; DeYoung 2000). The general deterrence of laws or measures for reducing a given risky behavior is important in the context of reducing overall given risky behavior across the whole population of drivers.

Thus, the studies in individual level measure the specific deterrence of the intervention primarily (McArthur and Kraus, 1999; DeYoung, 1999). The general deterrence of the policy may be measured in the aggregate level study (Rogers and Schoenig, 1994; DeYoung, 2000). While the specific deterrence is limited to traffic offenders only, the general deterrence is expanded its deterrence to the potential ones. Moreover, the specific deter effect of drunk driving measures are estimated under 10% from meta-analysis conducted by Wells-Parker et al. (1995). The general deter effect of drunk driving measures may be estimated higher than 10% (Rogers and Schoenig, 1994; Chang and Yeh, 2003a). However, one measure or intervention has a specific deterrent effect doesn't mean that has a general deterrent effect. Some intervention has been found to have a significant specific deterrent effect, but has an insignificant general deterrent effect (DeYoung, 1999, 2000). Rather, maximizing the general deterrence seems more important for authorities due to the larger size of the effect and its influencing scope.

Drunk driving problem not only resulted in many road accidents but also imposed huge costs to one society (Miller and Blewden, 2001). Thus, drunk driving problem is received major concerned in many countries (Rogers and Schoenig, 1994; Gruenewald and Ponicki, 1995; Wells-Parker et al., 1995; Deshapriya and Iwase, 1996; Ruhm, 1996; Roeper and Voas, 1998; Taxman and Piquero, 1998; Peek-Asa, 1999; McArthur and Kraus, 1999; Frick et al., 2000; Miller and Blewden, 2001; Voas and DeYoung, 2002; Chang and Yeh, 2003a). Much research on this issue has been conducted from different fields, such as road safety (Rogers and Schoenig, 1994; Gruenewald and Ponicki, 1995; Wells-Parker et al., 1995; Deshapriya and Iwase, 1996; Roeper and Voas, 1998; Voas et al., 2000; Voas and DeYoung, 2002;), public health (Peek-Asa, 1999; McArthur and Kraus, 1999; Frick et al., 2000; Rehn and

Gerhard, 2001), economic (Ruhm, 1996), and criminal science (Taxman and Piquero, 1998). This problem also has been concerned in Taiwan due to opening of the alcohol-related product market (Chang and Yeh, 2003ab).

The specific deterrence and general deterrence of different measures in alcohol-related crashes reduction are examined very much in past literature. However, the temporal variation of the effect of measures has been received less attention in literature (Chang and Yeh, 2003ab). Hauer (1997) mentioned the effect of road safety measures has temporal variation. Also, in one study concerning the effects of drunk driving prevention measures in Taiwan (Chang and Yeh, 2003a) also indicated that there is the temporal variation on the effect of the safety intervention.

The conventional methods employed to measure the effect of an intervention policy regarding accident reduction can be classified into three categories. They are: pair-t test, time series analysis, and causal factor analysis (Hauer, 1997; Lacey and Jones, 2000; Chang and Yeh, 2003a). In the pair-t test approach, the average accident frequencies (or accident rates) before and after implementing the intervention policy are collected respectively, and the pair-t test is then applied to determine whether these two average values are significantly different. Two problems are noted when using the pair-t test to measure the safety effect. First, the accident reduction cannot guarantee to be the result of the intervention policy for lack of comparison with controlled counterparts. Second, if the safety effect following the implementation of a policy is not constant over time, how long after implementation will be the right time to measure its safety effect?

Time series analysis is another commonly used evaluation approach for measuring the safety effect of an intervention policy. Through model estimation and prediction, time series analysis can explore the trend of accident occurrences over

time, and help the analysts to determine whether the intervention policy was effective in reducing the rate of traffic accidents. However, time series analysis is argued by its inherent drawback that it cannot discern the specific effects of individual factors affecting the accident occurrence. Although this drawback could be somewhat improved by applying a multivariate time series model instead of a univariate time series model, nevertheless, the complicated technical requirements for modeling and computing often discourage the analysts from trying to do so. Furthermore, time series analysis involves a considerable amount of “data mining” and needs more observational data in evaluating the safety effect (Rogers and Schoenig, 1994; DeYoung, 2000; Rehn and Gerhard, 2001). The end-result is that the evaluation work is unable to be conducted within a short period after the implementation of the intervention policy.

Causal factor analysis is the most popular tool for evaluating the safety effect of policy intervention (Miaou, 1994; Dionne et al., 1995; Agresti, 1996; Sohn, 1999; Li et al., 2001; Chang and Yeh, 2003a). This type of regression model is usually estimated by the least squares or maximum likelihood estimation methods (Agresti, 1996). The capability of differentiating the safety effect of policy intervention from other factors makes the causal factor analysis model superior to other models. However in the literature, the effect of a policy intervention is commonly formulated by a dummy variable in the causal factor analysis models, like the linear regression or Poisson regression models (Miaou, 1994; Chang and Yeh, 2003a). It only shows the average safety effect of the intervening policy over the study period, and fails to see the temporal variation of the safety effect during its evolution process.

Thus, exploring the temporal variation of road safety policies and measuring its temporal effects quantitatively is an important research issue in the field of road

safety.

2.2 The safety impacts of deregulation on transportation

The transportation industries, such as airlines, trucking, and bus transportation, in developed countries have been deregulated since 1970s and 1980s (Chow, 1987; Capelle and Beilock, 1987; Jerome, 1985; Evans, 1994; White et al., 1995; White, 1995). In addition to the economic effects of deregulation of transportation industries, the safety impacts of deregulation had received much attention. The past literature shows that no deterioration of safety performance was found after deregulation of the bus and coach industries in Britain (Evans, 1994; White et al., 1995; White, 1995) as well as deregulation of the trucking and airline industries in the United States (Chow, 1987; Capelle and Beilock, 1987; Jerome, 1985). However, some studies indicated that the deregulation of the trucking industry was found to change the behavior of the carriers, and influence their safety performance (Chow, 1989; Corsi and Fanara, 1989; Jovanis, 1989).

Organizational factors, which include firm size, fleet age, fleet size, operational mileage, type of cargo, and compliance with safety regulations, have been found to significantly affect the carriers' safety performance in the trucking industry (Corsi and Fanara, 1989; Moses and Savage, 1992, 1994; Mejza, 1998; Arnold and Hartley, 2001). The associations between safety performance and company characteristics, including the type of operation and the size of fleet, were also explored recently for passenger motor carriers (Corsi et al., 2002).

The past literature has provided the inconsistent conclusions regarding the impacts of deregulation on the safety performance of individual carriers and the transport industry as a whole. Thus, to explore why the inconsistent conclusions have

been obtained in past literature is another important issue. In addition, it is interesting to find out which kinds of safety policy implications may improve the safety performance of bus companies in the era of post economic deregulation.

CHAPTER 3

Safety Effects of Drunk Driving Prevention Policy over Time

Neglecting the time variable of the safety effect may cause the effect of the policy to be misunderstood by researchers, and lead the relevant authorities to make poor decisions concerning the status, enhancement or replacement, of the existing policy. The temporal safety effect problem was mentioned by Hauer (1997); however, little attention has been paid on measuring its effect quantitatively in past literature. Thus, this chapter aims to explore the factors affecting the safety effect of an intervention policy, and to determine whether the time variability of the policy effect exists.

In the following part, the life cycle theory (Wells and Gubar, 1966; Robbins, 1990; Kolter, 1994) was applied to develop a conceptual framework of the changing safety effect pattern brought about by the intervention policy over time. A Poisson regression model was used to formulate the relationship between the monthly accident frequencies and the candidate affecting factors, as well as the time following the implementation of the intervention policy. The implementation of criminal sanctions for drunk driving (CSFDD) in Taipei City was then taken as an empirical example to determine whether the time variability of the safety effect really existed for the CSFDD.

3.1 A Conceptual Framework for the Life Cycle of Safety Policy

A life cycle refers to a growth pattern with predictable change over time. The

CHAPTER 4

Potential Fallacies in Measuring the Effects of Drunk Driving Prevention Policy

In previous chapter, we developed the method to measure the temporal variation of the safety effect for the drunk driving prevention policy. The results provided strong evidence to prove that the effects of safety measures on accident reduction vary over time. Therefore, no matter what approaches, such as pair-t tests, causal factor analysis with dummy, and causal factor analysis with time-based specifications, we use to evaluate the effect of an intervention policy, we will face the same problem about how long the observation periods before and after implementing the policy should be used if we recognize the existence of the temporal variation of the policy effect.

Two contradictory issues are noted when measuring the safety effect of an intervention policy. That is, the randomness of accident occurrence requires that the before and after observation periods should be long enough in order to measure the safety effect of the intervention policy with sufficient statistical power. However, on the other side, the longer the before and after observation periods are used, the more possible the affecting factors will change. Thus, if we fail to manipulate this problem adequately, we might make a wrong conclusion to the effect of an intervention policy.

This chapter presents how profoundly the temporal variation of the policy effect can affect the results of measuring the safety effect of an intervention policy by using different lengths of study periods before and after implementing the policy. The potential fallacies of applying the pair-t test, causal factor analysis model with dummy specification, and causal factor analysis model with time-based specification to

CHAPTER 5

Safety Performance of Bus Companies after Deregulation

According to literature review in safety impacts of deregulation, there is a possibility that deregulation of the transport industry will change the organizational and operational characteristics of individual carriers, and restructure the companies within the industry. Deregulation is then expected to impact in different ways, positive or negative, upon the safety performance of carriers with different characteristics, and have an overall impact on the industry as a whole. If this assumption is true, we might be able to shed some light on the reasons for the inconsistent conclusions regarding the impacts of deregulation on the safety performance of individual carriers and the transport industry as a whole.

Deregulation of the intercity bus market in Taiwan has provided the opportunity to study the relationship between safety performance and organizational as well as operational characteristics of individual carriers, and to review the actual effect of deregulation on safety performance. Hence, this chapter aims to explore the environmental and organizational factors that affect the accident risk of bus companies, and provides valuable information to help both regulators and bus companies to make the right decisions concerning safety management programs.

This chapter organizes as follows. A conceptual framework for the safety performance of bus companies, based on the organizational accident theory is first developed in 5.1. The deregulation of intercity bus service in Taiwan is introduced in 5.2, and the measurement of the variables for model formulation is prepared in 5.3. The data collected for this study are presented in 5.4. Model estimation results are

CHAPTER 6

Conclusion and future study

6.1 Conclusion

This study tries to handle two road safety-related policies. First topic aims to measure the temporal effects of the accident prevention policy, and second topic is to explore the impacts of deregulation on safety performance of bus companies.

In first part of this study, the theory of life cycle was used to describe the effect of an intervening policy over time, and four possible safety effect patterns observed within an observation period were introduced. An evaluation of the effect of the “criminal sanction for drunk driving (CSFDD)” policy over time in Taipei City was conducted as an empirical example to demonstrate the existence of temporal variation for the effect of this preventive policy.

Poisson regression models with dummy-based and time-based specifications were developed to provide an insight into the occurrence of alcohol-related fatal accidents. The estimated results of the preferred dummy-based specification model showed that both the use of alcohol and the implementation of the CSFDD policy had significant effects on reducing the occurrence of alcohol-related fatal accidents, but that the enforcement devotion had only a marginally significant effect. The results indicated that the CSFDD policy reduced the expected number of alcohol-related fatal accidents on average by 72.6% over the 20 months following its implementation.

The results of the time-based specification models indicated the quadratic function of natural logarithm transformation of time elapsed (i.e. $\ln(1+t')$), could reasonably catch the safety effect pattern of the CSFDD policy over time. Thus, it

implied the effect of the CSFDD policy appeared to be a rapid initial followed by a slow decay. As expected, both the number of drunk driving offenders arrested, and the yearly alcohol sales index appeared to have significant effects on the occurrence of fatal accidents involving drunk driving. All of the four stages introduced by the life cycle theory were observed in this empirical example, and the temporal variation for the safety effect of the CSFDD was verified in this study. The time-based specification model was demonstrated to be better than the dummy-based specification model in evaluating the effect of safety policy on reducing the alcohol-related crashes here.

In addition, the issue regarding the potential fallacies in measuring the effects of the policies with different observational periods is also demonstrated in Chapter 4. The aim is simply to show that the different observation periods may greatly influence results. Applying the pair-t tests to measure the effect of the CSFDD with different observation periods indicates that the choice of the lengths of the post-implementation periods will determine whether the effect of the CSFDD was significant, and the amount on reducing the number of alcohol-related fatal accidents. The results show that the length choice for the post implementation periods seems to be more sensible than that for the prior implementation periods in measuring the safety effect of the CSFDD.

Causal factor analysis techniques with the dummy specification are able to estimate the effect of road accident prevention policies with controlling other influencing factors. However, the similar problem arose from this analysis method in measuring the effect of the policy. The results not only show the different size of effects for the models with different lengths of observation periods, but also show that the length of the post implementation period is more sensible in measuring the effect

of the CSFDD. Also, the length of the prior observation period is found to be more important in measuring the effects of the other factors.

The results estimated from time based specification models indicate that the models with the shorter post implementation periods may obtain the increasing pattern of the policy effect, but the models with the longer post implementation periods obtain the policy with the rapid initial response followed with a period of decay. The longer post implementation period is suggested more appropriate than the shorter post implementation periods in model estimation. All approaches used to evaluate the effect of an intervention policy indicate that the choice of the length of observation period will profoundly affect the results. Thus, analysts should be more careful in interpreting their evaluation results estimated by an observation period carefully to avoid making an inappropriate conclusion.

Although the appropriate length of observation period is not available, we suggest that the continual monitoring of the policy effect over its evolution process may be more beneficial for analysts in evaluation of road safety measures as well as for authorities in road safety management.

The second part of this study aims to explore the factors affecting the safety performance of bus companies. A conceptual framework was developed based on the theory of organizational accidents, and environmental and organizational factors were assumed to determine the safety performance of bus companies. The deregulation of intercity passenger transportation in 1995 brought about the restructuring of the bus transportation industry in Taiwan, and provided an opportunity to gain an insight into the factors that influence the safety performance of bus companies.

All the bus companies in Taiwan were asked to provide the relevant information

for the year 2001 through their general managers or representatives through a questionnaire. Forty-two bus companies that replied, except for the only intercity bus company established before deregulation, were then divided into three types of bus companies. They were, the new bus companies, the existing bus companies that joined the new intercity bus service, and the existing bus companies that did not join the intercity bus service.

Although the operational and organizational characteristics among these three types of bus companies are apparently different, nevertheless, the results of the ANOVA show that the exposure-based accident rates among the three types of bus companies are not significantly different. Based on this particular study result, we might conclude that the deregulation of the intercity bus service would not deteriorate the safety performance of the bus transport industry as a whole, and that no actions were required to improve the safety performance. However, when we applied the causal factor analysis models to relate the safety performance of bus companies with their operation and organization characteristics, we found that the safety performance was in fact affected by the characteristics of bus companies. The effects of those influencing factors might be positive or negative. If the deregulation was implemented with some safety regulation policies, we might have the opportunity to pursue a better safety performance by the bus transport industry as a whole, rather than just prevent the deterioration of the existing safety performance.

The results show that two environmental factors and five organizational factors of bus companies significantly affected their safety performance, and that different environmental and organizational factors impacted significantly on the occurrence of different accidents in terms of their injury severity. While the newcomers after deregulation did not experience a higher accident risk than the others, the novice

operators of the intercity bus service appeared to have a higher accident risk than the others.

All five organizational factors were found to have significant effects on the safety performance of bus companies. Especially, the average number of traffic convictions, excluding parking violations, the proportion of vehicles aged less than 5 years, and the capital of the bus company were the most significant to affect the occurrence of all kinds of accidents. Although the mechanical failure rate and the driver to non-driver staff ratio were only significant for the occurrence of PDO accidents, they might result in more severe injury accidents in the long run according to the theory of “the continuum of events” proposed by Hauer (1997).

Finally, in order to improve the safety performance of bus companies as a whole, we suggest that some safety improvement policies, including vehicle regulations, thresholds of capital, assistance for novice operators and monitoring higher risk companies, to be conducted in conjunction with the implementation of economic deregulation.

6.2 Future study

Although we found the temporal variation of the effect of drunk driving policy existed in this study, the issue concerning the mechanism that results in the temporal variation of safety effects for these intervening policies over their lives is not investigated in this study. Thus, the more in-depth studies should be conducted in the future on the factors affecting the temporal variation of intervening policies over their lives.

For lack of reliable and available information about the devotion of enforcement to the CSFDD policy, the number of drunk driving offenders arrested by police was

used as a proxy variable to represent the enforcement devotion in this study. Some more appropriate data for the enforcement devotion should be considered in further studies. And, the information about the use of alcohol and the use of different types of alcoholic products, such as liquor versus beer versus wine consumption has met with similar problems as did the enforcement devotion.

In order to catch the possible patterns of the accident prevention policies, we suggest that more functional forms (e.g. piecewise linear or nonlinear) about the safety effect patterns over time should be investigated in the future studies. Although we found the adoption of alcohol control policies may be a beneficial direction for reducing alcohol-related accidents, the influences of the alcohol control policies on multi-dimensions, such as economic, international relationship, social, safety, and etc., should be evaluated carefully before adoption of such policies.

Although organizational and environmental factors have been found to affect safety performance of individual bus companies, the issues regarding the influences of organizational cultural factors in safety performance has not been investigated in this study and needs further investigation.

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Appendix A: The alcohol-related fatal crashes data

Fig. A.1 The alcohol-related fatal accidents in Taipei during the study period(1996.3~2000.12)*

編號	月/年	次數	編號	月/年	次數	編號	月/年	次數
1	03/85	2	21	11/86	7	41	07/88	1
2	04/85	5	22	12/86	1	42	08/88	0
3	05/85	3	23	01/87	3	43	09/88	0
4	06/85	2	24	02/87	0	44	10/88	1
5	07/85	4	25	03/87	1	45	11/88	0
6	08/85	2	26	04/87	0	46	12/88	0
7	09/85	6	27	05/87	0	47	01/89	1
8	10/85	5	28	06/87	0	48	02/89	2
9	11/85	2	29	07/87	0	49	03/89	1
10	12/85	4	30	08/87	2	50	04/89	2
11	01/86	0	31	09/87	4	51	05/89	3
12	02/86	3	32	10/87	1	52	06/89	3
13	03/86	1	33	11/87	2	53	07/89	2
14	04/86	1	34	12/87	3	54	08/89	2
15	05/86	3	35	01/88	4	55	09/89	2
16	06/86	1	36	02/88	1	56	10/89	2
17	07/86	1	37	03/88	1	57	11/89	4
18	08/86	0	38	04/88	1	58	12/89	0
19	09/86	0	39**	05/88	1			
20	10/86	1	40	06/88	1			

*Data source: Chang and Yeh (2003)

**CSFDD was started to implement

Appendix B: The questionnaire for bus companies

親愛「姓」「職銜」您好：

在國內汽車客運運輸業中面臨嚴峻的競爭挑戰下，除了在經營績效上遭遇到嚴重的難題，即時行車安全問題亦受政府與大眾關切指責。在雙重壓力下，想必讓身為經營者的您感到非常頭痛。即時國內學術單位鮮少投入汽車客運運輸業之相關研究，可能讓您覺得更無助。

我目前所進行之博士論文研究的主題即在探討汽車客運運輸業組織經營管理因子與行車安全績效關係。此份論文主要目的公司整體與駕駛員個體兩方面著手切入，探討公司之組織文化、經營管理因子與行車安全表現間之關係，可作為汽車客運運輸業者改善行車安全之參考。這份研究在身為道安委員會委員 張新立教授指導下進行，張教授多年來非常關心國內汽車運輸業之經營與行車安全議題，亦有指導碩士班學生之論文探討國道客運服務品質問題。

本研究所期望達到的研究目標，極度需要國內汽車客運業者大力協助提供實際資料以提供研究之所需。因此，此研究之成功與否必須仰賴 您提供貴公司最寶貴且真實的資料才能夠順利進行。您所提供之資料將作為建立國內汽車客運運輸業組織管理因子與行車安全績效間之總體關係模式之用。這份研究之結果可以提供貴公司參考比較與國內各汽車客運公司總體行車安全績效間之差異，協助您掌握提升行車安全之因子，以及瞭解其他公司總體表現。在此非常懇切地請您提供貴公司最真實的資料，這些寶貴資料僅僅作為學術分析研究之用，不會有個別資料洩漏，請您放心作答。本研究之成果未來將採取總體方式呈現出來，並不會有個別公司單獨呈現的問題。因此懇請您務必撥冗填答，若您實在撥不出時間來，亦請您指派一位全盤瞭解貴公司整體業務之經理級或相當職階人員負責填答，以提供最詳實且寶貴的資料。懇請您儘量在七月五日前作答完畢，將問卷以所附中郵信封交寄。

最後感謝您的協助

敬祝

公司業務蒸蒸日上，鴻圖大展

國立交通大學運輸科技與管理學系教授 張新立博士

國立交通大學科技與管理學系博士候選人 葉純志 敬上

(若有疑問，請洽 0939812148 或 taiwan.ceo@msa.hinet.net 葉純志)

一、公司基本資料

- (1)公司名稱：_____；填答人姓名：_____；擔任職位：_____
- 聯絡電話：(0____)_____轉_____
- (2)公司資本額為：_____億元；公司總員工數(含行政人員)：_____人；
- 公司總駕駛員數：_____人；其中跑市區路線者：_____人；
- 國道路線者：_____人；負責一般鄉鎮間公路路線者：_____人；
- 其他路線司機數：_____人。
- (3)公司設立至今已有幾年：_____年
- (4)公司為☐市區汽車客運業☐公路汽車客運業☐其他：_____
- (5)公司經營路線主要為(可複選)
- ☐市區路線☐鄉鎮市或跨縣市路線☐國道路線☐其他：_____。
- (6)公司的總行車路線數：_____條；其中國道路線：_____條；市區路線：_____條；一般鄉鎮間公路路線：_____條；其他路線：_____條。

二、公司營運車隊資料

- (1)公司用於營運用之車輛(不含非營運用車輛)總數：_____輛；
- (2)貴公司營運用車輛之車齡分布資料：

車齡	營業客車車輛數
少於一年	
一年至三年間	
三年到五年	
五年到七年	
七年到十年	
十年以上	

三、營運車輛安全表現資料

- (1)請提供貴公司在民國九十年內之行車安全績效表現

年度	死亡肇事案件數(指有人在廿四小時內死亡者)	重傷肇事案件數(指有人受傷需要住院三天以上者或廿四小時後死亡者)	輕傷肇事事件數(指有人受傷住院三日以下或無須住院者)	僅有財產損失件數(指財物損失達五千元以上者)	車輛在路途中故障次數
民國 90 年					

年度	行駛中違規次數	停車違規次數
民國 90 年		

- (2)請提供貴公司民國 90 年內營業車輛總行駛里程數與載客量

年度	行駛里程數(萬公里)	載客量(萬人)
民國 90 年		

Appendix C: The List for Replied Bus companies

編號	公司名稱	編號	公司名稱
A001	基隆公車處	A022	屏東客運
A002	基隆客運	A023	高雄市公車處
A003	台北市公車處	A024	金門車船處
A004	國光客運	A025	員林客運
A005	光華巴士	A026	台聯汽車
A006	亞通客運	A027	中興大業
A007	台北客運	A028	指南客運
A008	首都客運	A029	淡水客運
A009	新店客運	A030	欣和客運
A010	宜興客運	A031	鼎東客運
A011	長航通運	A032	豐原客運
A012	汎航通運	A033	興南客運
A013	新竹客運	A034	統聯客運
A014	苗栗客運	A035	花蓮客運
A015	巨業客運	A036	澎湖公車處
A016	台中客運	A037	大南客運
A017	總達客運	A038	大有客運
A018	彰化客運	A039	欣欣客運
A019	日統客運	A040	濱海客運
A020	嘉義客運	A041	和欣客運
A021	台南客運	A042	桃園客運

Vita

Chun-Chih Yeh was born in Hsinchu, Taiwan, on October 5, 1973. After graduation from Hsinchu Senior High School, he entered National Chiao Tung University, Hsinchu, and received his Bachelor degree in Transportation Engineering and Management in June of 1995. He entered the graduate school of National Chiao Tung University in September of 1995. Then, he kept on studying his education in the Ph.D. program of Transportation Technology and Management of National Chiao Tung University in February of 1997. His major interests are Transportation safety, Risk management, Transport policy evaluation, Management of Transport industries, Safety engineering and management. He received his Ph.D. degree in September of 2003.

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學 歷：

民國 92 年 9 月 國立交通大學運輸科技與管理學系博士班畢業

民國 86 年 2 月 國立交通大學運輸工程與管理學系碩士班肄業

民國 84 年 6 月 國立交通大學運輸工程與管理學系畢業

民國 80 年 6 月 國立新竹中學

榮 譽 民國 84 年 6 月 中華民國斐陶斐榮譽會員

資 格 民國 90 年 11 月 交通行政高等考試第三級及格

學術相關著作資料:

A.期刊論文(Journal paper)

1. Chang, Hsin-Li, and Yeh, Chun-Chih, 2003. The Life Cycle of the Policy for Preventing Road Accidents: An Empirical Example of the Policy for Reducing Drunk Driving Crashes in Taipei. Accident Analysis and Prevention (Accepted 23 July, 2003, Forthcoming).(SSCI, EI, 0.75)
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- 4.張新立、葉純志，2003.「酒後駕車防治措施成效之監控與評估-以台北市為例」，運輸計畫季刊第三十二卷第一期，pp. 131-150。
5. 葉純志、羅仕京、黃銘崇、徐慧芬，「大眾捷運系統投資模式體制之研究」，都市交通季刊第十四卷第二期，民國88年6月，pp.30~46。
6. 張新立、葉純志、黃歆嵐、徐德霖、張則斌，「新舊強制汽車責任險之比較與民眾認知程度之研究」，保險專刊第 52 期，財團法人保險事業發展中心編印，民國 87 年 6 月，pp56~69。

B.研討會論文 (Conference paper)

- 1.Chang, Hsin-Li, Yeh, Chun-Chih, 2001 ."THE RELATIONSHIP BETWEEN THE WORKING PRESSURE AND ACCIDENT RISKS FOR AGGREGATE-HAULING VEHICLE DRIVERS IN TAIWAN", EAST Annual Conference Proceeding, 2001.10.
2. 張新立、葉純志，「以敘述性偏好法構建停車執法對違規停車行為影響之研究－以台北市為例」，八十六年道路交通安全與執法研討會論文集，pp.85~pp.96，民國86年6月。
- 3.張新立、葉純志、張寶丹，「國小學童上下學交通管理規劃之調查研究－以台北縣為例」，中華民國第四屆運輸安全研討會論文集，pp.435~pp.444，民國86年11月。

- 4.張新立、葉純志，「我國公共停車費率政策之研究」，中華民國運輸學會第十二屆學術論文研討會論文集，pp.561~pp.573，民國86年12月。
- 5.張新立、黃歆嵐、徐德霖、張則斌、葉純志，「新舊強制汽車責任保險之比較與民眾認知程度之研究」，中華民國第一屆交通安全教育學術研討會論文集，民國87年5月15日，pp101~pp116。
- 6.張新立、葉純志、余健泉、黃歆嵐、張則斌、林維宏，「提高機車強制責任保險投保率之策略研究」，中華民國第二屆機車交通安全研討會學術論文集，民國87年10月23日，pp.243~pp.257
- 7.張新立、葉純志、黃歆嵐、徐德霖、張則斌，「新制強制汽車責任險之剖析與相關問題之探討」，中華民國第五屆運輸安全研討會學術論文集，民國87年11月20日（台灣大學土木所主辦）。
- 8.葉純志、羅仕京、黃銘崇、徐慧芬，「大眾捷運系統投資模式體制之研究」，中華民國運輸學會第十三屆論文研討會學術論文集，民國87年12月19日，pp519~526。
- 9.張新立、葉純志、張則斌、黃歆嵐，「強化執法人員對「強制汽車責任保險」政策執行力之研究-監理單位與警察單位」，88年道路交通安全與執法研討會論文集，桃園縣，民國88年6月，pp.23~36。
- 10.張新立、葉純志、張則斌，「強制汽車責任保險制度之設計與評估」，1999風險管理與保險經營學術及實務研討會論文集，高雄縣，民國88年5月，pp.329~354。
- 11.蔡明志、葉純志、林金美、蘇建誌，「砂石車駕駛人工作環境與違規肇事之相互關係探討個案分析研究」，砂石車安全管理研討會論文集，民國88年9月。
- 12.張新立、蔡明志、葉純志，「砂石車駕駛人肇事風險與工作環境互動關係之探討」，中華民國第六屆運輸安全研討會論文集，民國88年11月，新竹市，pp.479~499。
- 13.張新立、蔡明志、洪敏三，「航空運輸安全風險管理與保險整合策略之研究」，中華民國第六屆運輸安全研討會論文集，民國88年11月，新竹市，pp.531~551。
- 14.張新立、葉純志，「強制汽車責任保險政策制度之評估研究」，中華民國第十四屆運輸學會年會論文集，民國88年12月，台北市。
- 15.張新立、吳宗修、王國川、葉純志、吳晉光，「國內外道路交通安全講習制度之比較研究」，89年道路交通安全與執法研討會論文集，桃園縣，民國89年6月，pp.255~270。
- 16.張新立、王國川、吳宗修、葉純志、黃歆嵐，「實施酒後駕車道安講習對道路交通安全之改善成效評估-以台北市為例」，中華民國第七屆運輸安全研討會論文集，民國89年11月，台北，pp.25-34。

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C. 研究報告及其他 (Research and others)

1. 新竹市國中國小學生上下學接送方式之規劃研究
計畫主持人：張新立 教授
研究期間：86/6~86/11
(新竹市政府委託)
2. 新竹科學園區短中長期運輸系統規劃
計畫主持人：張新立教授
研究期間：86/7~87/6
(科學工業園區管理局委託)
3. 台中港未來競爭力分析及核心能力建立整體規劃分析研究
計畫主持人：謝尙行 副教授
研究期間：87/3~87/12
(台中港務局委託)
4. 「強制汽車責任保險政策」制度面與執行面評估暨相關配合措施之研究
計畫主持人：張新立 教授
研究期間：87/8~88/1
(財團法人保險事業發展中心委託)
5. 戰備道存廢及道路安全之研究 (國科會計劃 NSC 88-2623-D-009-001)
計畫主持人：張新立教授
研究期間：87/7~88/6。
6. 新竹科學工業園區主要幹道拓寬、動線規劃暨綠地多目標使用規劃
計畫主持人：張新立教授
研究期間：87/10~88/5
(科學工業園區管理局委託)
7. 新竹市機車停車管理之規劃
計畫主持人：張新立教授
研究期間：88/1~88/8
(財團法人山葉機車崇學基金會委託)
8. 道路交通安全講習現況探討及未來講習制度改善之研究
計畫主持人：張新立教授

研究期間：89/1~90/1（交通部交通運輸研究所）

9.以組織觀點探討陸路商用運輸業安全風險管理之研究

計畫主持人：張新立教授

研究期間：89/8~90/7（國科會 NSC89-2211-E009-079）