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DEVELOPMENT OF FREEWAY SERVICE PATROL PROGRAM IN CHINA: A NEW PERSPECTIVE FROM FUNDS AND INSTITUTIONAL MANAGEMENT

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ABSTRACT

This paper analyzed institutional issues especially on funding sources and institutional management that are very critical to successful building up and operating freeway service patrols (FSPs) Programs. The goal of this research was to determine the suitable funding sources and institutional management structures for FSPs considering the real institutional situation in different provinces. To achieve this objective, we first classified the freeway financial and investment institutional structures (FFIS) into four types i.e., DOT centralized management structure (DOTCMS), state-owned enterprise centralized management structure (SOECMS), Hybrid of DOT and state-owned enterprise management structure (HMS), and Decentralized management structure (DMS). Based on the FFIS, the most suitable tollway fees structures and the FSPs institutional management structures were identified. In order to deal with the drawbacks of other structures which already adopted in provinces, the authors suggested establishing the Provincial Freeway Cooperation Commission (PFCC). PFCC intensively managed the tollway fees revenues and expense, and set coordinators for multi-agencies cooperation. In this way, the drawbacks of institutional management of freeway would be significantly reduced and incident management system and FSPs would be successfully implemented. This paper provided a new perspective to fully understanding the FSPs institutional issues which are critical to FSPs program successful implementation. The research could be also directly aid policy-makers from different provinces in China and also be useful to other countries.

INTRODUCTION

Freeway service patrols (FSPs) are, typically, programs that use specially equipped vehicles to patrol congested or high-incident freeways searching for traffic incidents. As one of popular incident management strategies, FSPs can more effectively integrate incident detection, response and clearance activities. By more accurate incident detecting and faster incident responding, FSPs can aid motorists and assist incident clearance quickly to reduce the incident duration. Based on the advantages of FSPs, service patrols have been widely operated in the U.S. in different forms. However, the relevant critical issues in the FSPs practice are also broadly studied by engineers and researchers in past decades.

From the literature, researches mainly focused on evaluating benefit/cost of FSPs programs, optimizing FSPs operation elements such as fleet allocation, and discussing the FSPs planning and institutional problems. There exists an extensive literature on evaluating benefit of FSPs programs by using simulation evaluation method (Ma et al., 2006; Pal and Sinha, 2002; Ozbay and Bartian, 2003) or statistic analysis method by comparing the pre and post FSPs data (Skabardonis et al. 1998; Garib et al., 1997; Morales J.M., 1996; Sullivan, 1997). The B/C ratios of different FSPs programs have significant differences and most B/C ratios of FSPs are more than 1.0(Singh, 2006). The varying ratios can be attributed to the different analysis scope (i.e., individual freeway corridor, freeways network in jurisdiction area), different regions and different operational variables (i.e., operation hours, FSPs function and fleet allocation). In FSPs operation practice, researchers mainly used simulation methods and operation research theory to optimize the operation variables choosing.

The institutional issues of FSPs planning and development are much less studied comparing with the other two issues. However, institutional issues especially on funding sources and institutional management are also very critical to FSPs programs successful building up and operation. FSPs system generally involves multiple jurisdictions, multiple agencies and multiple resources (Dickey and Santos, 2011), and thus requires more cooperation and fully preparation among various agencies. Baird 2003(Baird and Jacobs, 2003) carefully described available practice experiences on planning and institutional development of Tennessee's FSPs (HELP) program. Five key aspects of FSPs that are critical to Tennessee's HELP program are successfully implemented—teamwork, human resources, training, vehicles and equipment, and communication, which could significantly improve understanding the FSPs managing. However, the details of funding sources of the HELP program have not been covered although the level of funding to authorize and funding sources were mentioned as key challenges. In *Federal Highway Administration Service Patrol Handbook 2008*(Houston et al., 2008), funding sources were considering as one of the essential fundamental components of FSPs programs. Funding not only definitely affects service patrols operation scheme such as patrol areas, service hours and equipment etc., but also was the ultimately factor to determine if FSPs programs can be sustained. It is no doubt that FSPs sponsor should first deal with the funding issues when developing a new FSP program. However, no systematic analysis on funding sources and institutional management of FSPs program has been found in the literature.

As a typical developing country, China is still in the freeway construction period and governments are still facing the limited funding sources for road construction and management. One of the main differences of freeway system between the U.S. and China is the amount of the toll freeway mileages. To further illustrating this difference, an interesting example is that 3250 kilometers round-trip by automobile from New York to Chicago cost a Chinese professor \$32 fee for using toll road (Zhang, 2011). While automobile traveling from Beijing to Hubei in the same mileages will cost \$280 road using fee in China. Obviously, the institutional environment of freeways system such as toll road building policy orientation cannot be ignored when discussing the funding and managing issues of FSPs system. From this point of view, the biggest challenges for FSPs program successful development in China are as follows:

- How to deal with funding issues of FSPs startup considering the real institutional environments of freeways system in China? Two critical tasks need to be detailed. Firstly, as the limited funding from governments fiscal allotment, the feasible FSPs funding sponsored by possible agencies should be identified. Secondly, the suitable funding sources structures for different provinces since provinces have various freeway financial and investment institutional structures (FFIIS).
- What kind of institutional management could be used for FSPs program managing? The reasons to discuss institutional management of FSPs are existence of multiple-agencies management and heterogeneous institutional management structures of freeways system among different provinces.

The paper aims to systematically analyze the institutional issues of FSPs programs startup in China. Special attention is given to aspects of the FSPs funding sources and FSPs institutional management. Combining with the real financial and investment institution of freeways system in provinces closely, this research tries to identify the funding sources for FSPs development. After that, the institutional management of FSPs is identified considering the disadvantages of multiple-agencies management and heterogeneous management institutions of freeways in provinces. This paper provided a new perspective to fully understand the FSPs institutional issues which are critical to FSPs program successful implementation. The research could be directly aid policy-makers from different provinces in China and also be useful to other countries.

FUNDING SOURCES

Comparison of funding sources between the U.S. and China

The FSPs programs are mainly sponsored by one public agency exclusively or multiple -public agencies, i.e., department of transportation (DOT), police agencies, and metropolitan transportation agencies while sometimes private agencies sponsor FSPs as supplement funding through Public-Private Partnerships (PPP). (Levinson et al., 2001; Owens, N., et al., 2010). As illustrated in telephone survey of 53 freeway service patrols in 22 states conducted by Feno in 1997(Fenno and Ogden, 1998), 74% of surveyed service patrols are sponsored by public agencies with 47% by DOT exclusively, 6% by police agencies exclusively and 21% by multiple-public agencies. Whereas, approximately 27% programs received private funding sources. Another newest survey of 24 service patrols conducted by Federal Highway Administration 2008 (Houston et al., 2008) illustrated that the most funding are from Federal funds, State funds, or combination of the two.

There are several of funding sources spending FSPs programs in the U.S. and all these funding sources can be classified as Federal funds, State funds, and private funds. As illustrated in Table1, Federal funds and State funds usually represent 80% and 20% respectively of FSPs program start-up money when the programs receive both funds. However, State funds would account for approximately 100% in the case of no Federal funds in support of FSPs programs. In certain cases, some private agencies such as CVS/pharmacy and private insurance companies launched FSPs programs (Houston et al., 2008).

As mentioned in introduction section, the biggest difference of freeway systems between the United States and China is mileage of toll roads. Approximately 4,700 km of toll roads represent as 6% of the total freeway mileage in the United States (Weiss, 2012). While 95% of the existing freeways mileage relies on charging tolls and nearly 80% of the total investment collected from bank loans and private capital as report form news conference hold by Ministry of Transport of the People's Republic (MOT) of China in March 23rd, 2011(He, 2011). Obviously, the characteristics of toll roads cannot be ignored when we analyze the possible funding sources for FSPs startup.

Actually, feasible funding sources for FSPs are limited in China. Generally, funding sources for highways development come from vehicle purchase tax, fuel tax, the central budget funds, domestic loans, foreign capital, local fiscal funds including province fiscal and municipal fiscal, enterprises and institutions capital, and other funds. As illustrated in Table 2, the entire founding source for freeway development can be classified as government fiscal funds including central funds and local funds, financial loans from enterprises and institutions capital (state-owned enterprise), and financial loans from domestic loans and foreign capital(Ruibo, 2006). Financial loans contributed the most to freeway investments (almost 80%-90%) comparing with only 6%-7% from government investment. In other words, nearly all the freeways need charge tolls and then spent the user fee on covering the cost and repaying the loans.

Table 1. The Funding Sources of FSPs Development in the U.S.

| Classification | Funding Sources | |
|----------------|--|---|
| Federal funds | Congestion Mitigation and air Quality funds (CMAQ) | Usually account for 80% of start-up money |
| | National Highway System (NHS) funds | |
| | Federal Surface Transportation funds | |
| | Metropolitan Planning Organization funds(MPO) | |
| State funds | State general revenue funds | Usually account for 20% of start-up money as match funds; however approximately 100% when there have no Federal funds |
| | State highway trust funds | |
| | State traffic and safety funds | |
| | State operations and maintenance funds | |
| Private funds | Private insurance company | In certain cases, usually as supplement funding through PPP |
| | Tollway Authority | |
| | Commercial organizations | |

Table 2. The Funding Sources of FSPs Development in China

| Classification | Funding Sources | Percentages |
|-----------------|--------------------------------------|--|
| Central funds | Vehicle purchase tax | Named as government investment, usually account for 6%-7% of the total freeway investments |
| | Central budget funds | |
| Local funds | Province fiscal funds | 60%-70% |
| | Municipal fiscal funds | |
| Financial loans | Domestic loans | Approximately 20% |
| | Enterprises and institutions capital | A small amount |
| | Foreign capital | |

Not all the funding sources mentioned above could be used for FSPs program in China. The possible funding sources for FSPs programs startup are local funds, tollway fees and commercial organizations capital. The reasons are explained as follows:

- Central funds including vehicle purchase tax and central budget funds usually are used for national freeway network and country road construction thus are not suitable for FSPs program. In order to ensure a certain benefit/cost ratio to start FSPs programs, FSPs programs definitely requires an amount of certain traffic flow and thus usually to be implemented several years later after freeway constructed. Basically, central funds will not be used for FSPs programs in recently unless that the freeway network construction is finished. Whereas, national freeway network will takes at least 10 years to complete according the *planning of the national freeway network* (Guang and Xiao, 2011).
- Similar to central funds, financial loans usually are invested as freeway construction capital. Thus, it will not be used for FSPs programs, especially when considering the certain rates of return on capital in the perspective of investors.
- Local funds including provincial fiscal funds and municipal fiscal funds can be used for FSPs program startup. After the implementation of “Reform and Opening-up” policy in 1979, the Chinese central government decentralized the main fiscal responsibility of highway development to local governments and state-owned enterprises which were mostly controlled by local governments. Thus the local governments have the responsibility of freeway operations and maintenance, and consider initiating the FSPs programs when it effectively reduces the incidents and improve traffic safety and efficiency.

Tollway fees is actually the mainly funds for FSPs programs startup. According to the *Regulation on the Administration of Toll Roads of the People's Republic of China* (Decree of the State Council (2004) no. 417), the toll road operating companies have the responsibility for traffic management facilities construction such as traffic signs and markings, road maintenance, and relevant traffic management to ensure the tollway service safety and quality. All the cost can be covered as regular operating expenditure using the tollway fees charged from the road user.

- Commercial organizations capital can enter into Public Private Partnerships (PPP) to supplement government funding for FSPs. In return, the service patrol vehicle or relevant website of FSPs programs can display the advertisements of commercial organizations.

Funding Sources Management Structures for FSPs Programs

As stated in the *Regulation on the Administration of Toll Roads of the People's Republic of China* (Decree of the State Council (2004) no. 417), tollway operating companies are responsible for traffic management and road maintenances, and all the cost of relevant facilities and equipment is directly covered by tollway fees charged from the road user. Thus FSPs, as one of important components of traffic incident management system, actually be funded from toll roads operating companies while commercial organizations capital and local funds act as just FSPs funds supplement. However, the tollway fees for FSPs startup (TTFs) have different structures because of the various FFIIS in provinces. In order to successfully implement the FSPs program, it is important to understand TTFs and identified certain strategies to deal with drawbacks of TTFs.

Classification of the freeway financial and investment institutional structures. Among 31 administrative units in Mainland China, there are 22 provinces (Hebei, Shaanxi, Liaoning, Jilin, Heilongjiang, Shandong, Shanxi, Henan, Jiangxi, Hunan, Hubei, Anhui, Fujian, Jiangsu, Zhejiang, Hainan, Guangdong, Sichuan, Guizhou, Yunan, Gansu, and Qinghai), 5 autonomous regions (Inner Mongolia, Guangxi, Ningxia, Tibet and Xinjiang), and 4 municipalities (Beijing, Tianjin, Shanghai, and Chongqing), the FFIIS are classified into four types i.e., DOT centralized management structure(DOTCMS), state-owned enterprise centralized management structure (SOECMS), Hybrid of DOT and state-owned enterprise management structure (HMS), and Decentralized management structure (DMS) based on their principal differences. Those different structures are:

- (1) DOT centralized management structure (DOTCMS) is used by department of transportation of Hunan and Liaoning Provinces. All freeways are intensively managed by provincial freeway management bureau (PFMB) which is one of administrative branches of DOT. PFMB not only plan the whole freeway financial and investment task, but also directly responsible for freeway charging, operation, maintenance, etc.
- (2) The state-owned enterprise centralized management structure (SOECMS) is used by Shandong and Anhui Provinces. The state-owned enterprise usually named as Transportation Investment Corporation (TIC) takes charge in freeway financial and investment task, credit repayment, freeway charging, operation and maintenance. All the freeways are intensively managed by one or several Transportation Investment Corporations. Note that TIC is also one of administrative branches of province government like DOT. In other words, DOT and TIC are in the same administrative level and DOT just provides certain guidance or suggestions for TIC.
- (3) Hybrid of DOT and state-owned enterprise management structure (HMS) is used by Henan and Hubei Provinces. Both DOT and TIC takes charge in certain amount of freeways financial and investment task, credit repayment, freeway charging, operation and maintenance. However, they separately managed the freeways in their respective jurisdiction.
- (4) Decentralized management structure (DMS) is used by Yunnan and Hainan Provinces. All the province-wide freeways are decentralized management by Freeway Operating Companies (FOC). One freeway corridor is one Freeway Operating Companies and FOC directly takes charge in freeway financial and investment, credit repayment, freeway charging, operation and maintenance. DOT just provides certain guidance or suggestions for FOC.

Tollway fees structures for FSPs programs startup. Based on the FFIIS, the tollway fees structures for FSPs programs startup are classified into three types i.e., vertical structure (VS), regional structure (RS) and decentralized structure (DS). As illustrated in Table.3, the provinces which adopted DOTCMS or SOECMS as the freeway financial and investment institutional structure are belong to vertical structure. In vertical structure, tollways fees are centralized managed by PFMB or TIC, thus DOT or TIC can systematically plan the FSPs programs in province-wide. Province-wide freeways in the province which adopted HMS are divided into several districts. In regional structure, DOT and TIC are responsible for funds to support FSPs programs separately in their jurisdictions. Decentralized structure existed in provinces which used DMS as freeway financial and investment institutional structure. In decentralized structure, one freeway corridor has a corresponding Freeway Operating Companies and tollway fees can only be used for their own operating companies to sponsor the FSPs program.

Obviously, the tollway fees structures are essentially caused by the freeway financial and investment institutional structures. Comparing with DS and RS, the tollway fees in VS is centralized management and could be used systematically in province-wide, thus decision-makers can plan and operate the FSPs programs as a whole. While in RS and DS, FSPs programs sponsor have to face the obstacles by multi-jurisdictions management because the tollway fees separately supported FSPs programs in a single freeway corridor or a district unites. As a result, the relevant sources such as funds, personals and equipments cannot be systematic optimized. These problems already existed in traffic incident management in Henan and Yunnan provinces.

Table 3. Characteristics of the Freeway Financial and Investment Institutional Structures

| | DOTCMS | SOECMS | HMS | DMS |
|---|--|--|--|--|
| Represented Province | Hunan and Liaoning provinces | Shandong and Anhui Provinces | Henan and Hubei Provinces | Yunnan and Hainan Provinces |
| Financing Main Entities | PFMB | TIC | Both of PFMB and TIC | FOC |
| Debt Obligation | PFMB load credit and to be paid off | TIC load credit and to be paid off | Both of PFMB and TIC load credit and to be paid off | FOC load credit and to be paid off |
| Administrative Relation between DOT and Freeway Operator | DOT takes charge of all relevant responsibilities, PFMB is one of administrative branches of DOT | DOT provide guidance for freeway development; Weak financing bonds between DOT and TIC | DOT provide guidance for freeway development; Weak financing bonds between DOT and TIC | DOT provide guidance for freeway development; Weak financing bonds between DOT and FOC |
| Tollway fees structures for FSPs programs | Vertical structure | Vertical structure | Regional structure | Decentralized structure |

Decision-making agency should find a way to manage the tollway fees intensively in province-wide and try to avoid using RS and DS tollway fees using structures. Freeway financial and investment institutional structures are necessary and hardly changed because these structures have the ability to provide sufficient funds and extremely stimulated the freeway development. However, it is possible to change the way of tollway fees management and expenditure. From the perspective of traffic network system, no single freeway section or corridor could be independent operated.

For example, the incident occurred in one freeway corridor could also lead to traffic congestion or traffic flow change on another freeway and thus the tollway fees revenues are significantly reduced. It is necessary to change the tollway fees separate management condition in the RS and DS to achieve the optimal network system. To accomplish this, a tollway fees management center should be established to intensively manage the tollway fees revenues and systematically spend for incident management.

INSTITUTIONAL MANAGEMENT STRUCTURE OF FSPs

The Agencies Involved in FSPs Programs

As one of important components of traffic incident management, FSPs programs cannot be operated as a stand-alone program. To restore traffic capacity safely and quickly, many different entities should closely cooperate and communicate to enhance the ability to detect, respond, assist, and recover. FSPs programs are often first on the scene after freeway incidents and are required to build trust and cooperation with other relevant agencies. Failing to recognize this, it is possible to result in failure to resolve incidents safely and efficiently.

From the experience of FSPs programs practice in the U.S. (Baird and Jacobs, 2003; 12 Houston et al., 2008), the following agencies can be involved when an incident occurs :

- Transportation agencies
- Law enforcement
- Fire and rescue services (HAZMAT, including clean-up and removal as needed)
- Towing and recovery companies
- Public and private information services
- Travelers and others using the affected system

Comparing with agencies in the U.S., the freeway operating commissions are also very important entities in China. According to the *Regulation on the Administration of Toll Roads of the People's Republic of China* (Decree of the State Council (2004) no. 417), the tollway operating companies are directly responsible for freeway operation and maintenance, etc. Most of those operating commissions are independent and have the same administrative power level with DOT or Law Enforcement agencies. This real characteristic of Chinese freeway management institution is actually the biggest difference between the U.S. and China. However, decision-makers have to face the plight of drawbacks of multi-agencies management because of this difference.

The main reason that caused this difference is the freeway development method used in China-tollways construction. As analyzed in previous section, there are four types of freeway financial and investment institutional structures, i.e., DOTCMS, SOECMS, HMS, and DMS. Obviously, the relationships among different agencies in these four types of structures are different, especially between DOT and freeway operator agencies. One of critical issues is to identify the suitable institutional structure for FSPs programs managing. Also, decision-makers need to know how to deal with the drawback of these structures.

FSPs institutional management structures

From the experiences on development of Tennessee's FSPs (HELP) program, the five most important factors contributed to successfully implementing HELP are teamwork, attention to human resources issues, comprehensive training, five-rate vehicle and equipment, and communication (Baird and Jacobs, 2003). However, these five factors have a basic feature in common if we further analyze those factors. The reason why we should pay more careful attention to these factors is that the inherent problems of the multi-agencies involved and multi-agencies management in FSPs programs.

As illustrated in Table 4, the characteristics of these four types of the FFIISs were analyzed by measuring difficulty of the agencies communication, comprehensive training, the standard of human resource establishment, vehicles and equipment system optimization, and teamwork. Obviously, DOTCMS is the best structure for FSPs implement. The main reason is that tollways are centralized management in DOTCMS and all the management units of FSPs are directly managed by DOT. While in DMS and HMS, these five key tasks are more difficult comparing with DOTCMS and this could be attributed to the drawbacks of multi-management agencies and decentralized management.

Table 4. The Characteristics of Four Types of the FFIISs

| | DOTCMS | SOECMS | HMS | DMS |
|---|---|---|---|---|
| Represented Province | Hunan and Liaoning provinces | Shandong and Anhui Provinces | Henan and Hubei Provinces | Yunnan and Hainan Provinces |
| Agencies Communication | Easy, all the FSPs are intensively managed | Easy; however, will more complicated with DOT | Most Difficult, exist multi-management | More Difficult, all the FSPs are separately operated |
| Complexity of Comprehensive Training | Easy, DOT can host and organize | Easy, TIC can host and organize | More Difficult, Both of DOT and TIC can host and organize | Difficult, FSPs are separately and hardly training |
| Establish the Standard of Human Resource | Easy, DOT takes charge of all relevant responsibilities | Easy, TIC takes the responsibility | More difficult, both DOT and TIC have themselves standard | Most difficult, Every single FOC has themselves standard |
| System Optimize Vehicles and equipment | Easy, all the vehicles and equipment can be used in province-wide | Easy, all the vehicles and equipment can be used in province-wide | More difficult, the vehicles and equipment used in their own Jurisdiction | Most difficult, The vehicles and equipment are used in their own companies. |
| Teamwork | Easy | Difficult | More difficult | Most difficult |

Unfortunately, the multi-agencies management problems existed in FSPs programs cannot be avoided in the current institutional situation, no matter in the U.S. or in China. However, we should try to reduce the losses caused by such institutional structure. In HMS and DMS, the agencies involved in FSPs work as highly independent entities and we need make those agencies closely work together to deal with the drawbacks of institutional structures.

DISCUSSION AND CONCLUSION

In China, the entire founding sources for freeway development can be classified as government fiscal funds including central funds and local funds, financial loans from enterprises and institutions capital (state-owned enterprise), and financial loans from domestic loans and foreign capital. However, not all the above mentioned funding sources could be used for FSPs programs in China. Notice that the biggest difference of freeway system between the U.S. and China is that the way funding the freeway development. In the U.S., the funding sources are mainly from fuel tax revenue. While in China, the funding sources are mainly from financial loans and different provinces have different freeway financial and investment institutional structures (FFIIS). Tollway fees charged from the road users are used to cover all the costs and repay the loans. Thus the tollway fees is actually the mainly funds for FSPs programs startup and other capitals are just supplement.

Based on the FFIIS, the tollway fees structures for FSPs programs startup are classified into three types i.e., vertical structure (VS), regional structure (RS) and decentralized structure (DS). Comparing these three structures, we found that it is necessary to change the tollway fees separate management condition in the RS and DS to achieve the optimal network system. While in the aspect of institutional management structure of FSPs, inherent problems of the multi-agencies involved and multi-agencies management in FSPs programs are very critical for FSPs successfully implementing. Analysis shows that DOTCMS is the best structure for FSPs implement. While in DMS and HMS, because the agencies involved in FSPs work as highly independent entities and decentralized management condition, the five key tasks are more difficult to accomplish.

In order to change the tollway fees separate management condition in the RS and DS and also deal with the drawbacks of institutional management structures caused by FFIIS, we suggest developing a specialized commission named Provincial Freeway Cooperation Commission (PFCC). There are three basic functions of PFCC: firstly, the tollway fees are intensively managed in order to change the tollway fees expense separately; secondly, all the agencies involved incident management(transportation, law enforcement, fire service, towing and media, etc.) transfer one or several representatives working in PFCC as coordinators; thirdly, the traffic management center which manages the traffic control and resources dispatching, and information distribution in province-wide is also established in the PFCC. In this way, the drawbacks of institutional management of freeway would be significantly mitigated and incident management system and FSPs would be successfully implemented.

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