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The wealth of knowledge accumulated during the 17th IRF World Meeting & Exhibition in Riyadh was the driving force behind our decision to launch the IRF Examiner as a freely available resource for the industry. With this seventh issue, the International Road Federation confirms its role as a leading provider of applied knowledge in areas of vital importance for the global community of road professionals.

H.E. Eng. Abdullah A. Al-Mogbel
IRF Chairman

Roads are the world's first "social network". They are fundamental building blocks for human and economic development whose impacts transcend national borders. The benefits of investments in roads have shown how transformative an infrastructure they can be for a wide range of beneficiary communities.

At the International Road Federation, we have tried to capture these connections with a simple slogan "Better Roads. Better World". Since we were established 1948, our primary purpose has been to transfer the latest technologies and knowledge from those who have it to those who need it, and in doing so, promote an agenda of shared prosperity that flows from accessible, affordable and sustainable road networks. The IRF Examiner is an essential vehicle to this ambitious agenda.

C. Patrick Sankey
IRF President & CEO

Currently, more than 1 billion people living in rural areas lack connectivity to the world's economy. 6 billion people will be living in cities by 2030, with massive mobility aspirations and needs. 1.5 million people die every year on account of traffic accidents and transport-induced air pollution — 92 percent in developing countries. Ensuring adequate and better targeted road expenditures combined with innovative financing for sustainable road transport will be critical to respond to the global connectivity requirements and the daunting mobility challenge ahead.

According to the McKinsey Global Institute, some US $16.6 trillion will be required in global road infrastructure investment during the years from 2013-2030, a sum that probably exceeds the current combined value of classified global road assets. Much of this investment will take place in today's developing world, where both connectivity needs and opportunities to promote a unsustainable development path are the greatest.

The papers in this issue of the *IRF Examiner* cover a range of innovative options for financing road investments and operations, as well as more effective road programming, budgeting and pricing. Such approaches aim variously to ensure more cost effective public expenditures, augment road funding beyond traditional financing methods, and help secure sustainable funding resources to enhance mobility and safety.

Dr. Asif Faiz
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A STUDY ON THE IMPROVEMENT OF PRIVATE FUNDED EXPRESSWAYS OPERATED BY A PUBLIC CORPORATION

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ABSTRACT

Although the Korean government controlled and managed expressways throughout the country until the 1990s, it started to accept private investments for constructing expressways for the past decade. As of 2014, 464 km of ten private expressways are under private operation, and 14 are planned with private investment.

This paper aims at developing an optimal operation model for public expressways by comparing the different operation method between private and public. The research result focuses on the reduction of operation cost and the efficiency of expressway operation system by studying the process of expressway operation, organization in charge of operation, human resources involved, and operation cost. Since personnel expenses take the largest proportion among costs, personnel reduction is the key factor for reducing the operation costs. Certain tasks required in the operation process should be outsourced to organizations to maintain cost effective services, not in conflict with public interest.

INTRODUCTION

The construction and operation of expressways used to be publicly funded business in most cases. Starting with the opening of the New Airport Highway in 2000, 10% of total expressways, - 10 routes consisting of 464km of roads in total - are currently being financed by private capital. The operation of a total of 24 privately funded expressways is planned. Out of 10 private expressways that are operated and managed by private entities, the Korea Expressway Corporation (KEC) is directly involved in the operation and maintenance of three routes: the Seoul-Chuncheon, the Busan-Ulsan, and the Seo (west) Suwon-Pyeongtaek, and has plans to manage an additional 11 private expressways following the integrated operation plan of the Ministry of Land, Transport and Maritime Affairs of Korea (MLTM) of the Republic of Korea.

However, those routes other than the three private routes directly managed by the KEC are on average less than 40km long, and inefficiencies result due to maintenance by a single business operator and the need for expressway users' to frequently stop for toll collection. Problems arise with private expressways whose average length is as short as 39km, because of toll collection and the need for different maintenance processes for their respective route, consequently causing user inconvenience, road congestion, and the increase in the operation cost. The government, with an eye on resolving such problems, developed the "Measures for the Integrated Operation of Private Expressways (MLTM, 2010)" based on which the integrated operation of two to three short-distance private expressways may be possible, therefore ultimately saving in maintenance fees through economies of scale and the improvement of customer convenience through the establishment of an integrated toll system.

In time, the operation cost of running private expressways is becoming more competitive, and the maintenance cost is also decreasing. Thus, the need to analyze the operation models of private expressways to make improvements was raised with the KEC, which will play a pivotal role in private expressways' maintenance according to the MLTM's Measures for the Integrated Operation of Private

Expressways. For the sake of the efficient operation of private expressways, it is important to make a comparative study with expressways already operated by existing private operators to find suitable improvement measures.

This study compares private expressways operated by the KEC and private operators in terms of operation and maintenance process, operation and maintenance organization, the number of office personnel, and the operation costs. Based on the findings, the study proposes measures to save on the operation costs and to improve efficiencies in the operation system for the 3 routes, which are operated by KEC. First, this study examined the adjustment of tollgate office personnel to make savings on the operation costs. Regarding outsourcing candidates, this study suggests several alternatives on the premise that possible violation of public interests is sufficiently taken into consideration. Also, new measures are proposed for the increase of profitability to bring about more eco-friendliness and efficiencies in spaces utilizing road assets, such as integrated facilities in rest areas and roadside areas.

CURRENT STATUS OF PRIVATE EXPRESSWAYS

Private investments started in earnest after the enactment of the Promotion of Private Capital into Social Overhead Capital Investment Act in 1994. Projects promoted since the enactment of the Act can be divided into three phases. The 1st phase was between August 1994 when the Act came into effect and December 1998 when the Act was revised to the Act on Public-Private Partnerships in Infrastructure. The 2nd phase was between January 1999 after the revision of the Act and December 2005, prior to the abrogation of the Minimum Revenue Guarantee (MRG). The 3rd phase was between 2006, at the time of abrogation of the MRG, and the present. As shown in Table 1, a total of 10 private expressways are in operations as of 2014, and 10 projects are under construction or under negotiation. Furthermore, the Pocheon-Hwado, the Songsan-Bongdam, and the Icheon-Osan routes are under current negotiation, and the Gongju-Cheongwon route is being proposed. A total of 24 private expressways are expected to be in operation by 2018.

Starting with the Incheon International Airport Expressway, private expressways started opening in the 2000s, such as the Cheonan-Nonsan, and the Daegu-Busan routes. The KEC, with an aim to secure business and improve its public perception, took charge of operating the Busan-Ulsan Highway in 2008, and the Seoul-Chuncheon Highway and the Seo Suwon-Pyeongtaek Highway in 2009 from private operators. The current status is shown in Table 2. The KEC plans to operate an additional 11 routes (excluding those in usage shown in Table 1, and the Gwangju-Wonju, the Songsan-Bongdam, the Seoul-Munsan Highways) according to the Measures for the Integrated Operation of Private Expressways (MLTM, 2010).

TABLE 1: Length of private expressways (as of 2014)

Status	Route	Length (km)
In usage	Incheon Intl. Airport	40.2
	Cheonan-Nonsan	81.0
	Daegu-Busan	82.0
	Ilsan-Toegyewon	36.3
	Busan-Ulsan	47.2
	Seoul-Chuncheon	61.4
	Seo Suwon-Pyeongtaek	38.5
	Incheon Bridge	12.3
	Yongin-Seoul	22.9
	Pyeongtaek-Siheung	42.6
Under construction	Suwon-Gwangmyeong	27.4
	Gwangju-Wonju	57.0
	Incheon-Gimpo	28.5
	Anyang-Seongnam	21.9
	Sangju-Yeongcheon	93.9
	Guri-Pocheon	50.5
	Busan new port 2nd back road	15.3
	Oksan-Ochang	12.1
Under negotiation	Gwangmyeong-Seoul	20.0
	Seoul-Munsan	35.6
* Total length of above 20 expressways: 826.6km (41.3km on average)		

TABLE 2: Private expressways operated and managed by KEC (as of 2014)

	Sum	Busan-Ulsan	Seoul-Chuncheon	Seo Suwon-Pyeongtaek
Operator	3 lines	Busan-Ulsan Exp. Corp.	Seoul-Chuncheon Exp. Corp	Gyeonggi Exp. Corp.
Contract date	-	24 July 2006	18 May 2009	17 August 2009
Length (km)	147.1	47.2	61.4	38.5
Operation period (yrs)	-	30	30	30

ESTABLISHMENT AND OPERATION OF THE PRIVATE EXPRESSWAY INTEGRATED SYSTEM

The method for performing integrated management is well explained in the Measures for the Integrated Operation of Private Expressways (MLTM, 2010). For the 10 private expressways currently in operation, there are 20 toll gates altogether to collect the toll fee for each route. When drivers take the private-funded expressways "Seo Suwon-Pyeongtaek → Suwon-Gwangmyeong route → Gwangmyeong-Seoul," they need to stop six times and pay the toll three times. Meanwhile, when they drive through the KEC-operated expressways "Gyeongbu line → Cheonan-Nonsan (Private) → Honam line," they only need to stop four times and pay the toll three times.

Toll Collection

For mutually connected private expressways, which are possible to integrate without investing additional costs, the toll collection is integrated as shown in Table 3 in order to minimize the number of stops and tollgate installation. As a mid-to-long term goal, the toll collection system is being integrated for public expressways operated by the KEC, and after the integration, KEC collects the toll and distributes it to each private operator. The cost may be saved for some routes by reducing the number of tollgates.

TABLE 3: Integrated toll collection system for private-invested expressways (MLTM, 2010)

	Routes	Length (km)	Number of toll gates
Toll Collection + Maintenance	Seo Suwon-Pyeongtaek + Suwon-Gwangmyeong + Gwangmyeong-Seoul	84.7	4
	Guri-Pocheon + Pocheon-Hwado	77.0	1
	Pyeongtaek-Siheung + Songsan-Bongdam	61.1	1
Only Maintenance	Seoul-Chuncheon + Hwado-Yangpyeong	80.0	-
	Ilsan-Toegyewon + Seoul-Munsan	71.0	-

Operation and Maintenance

Private expressways, whose average length is currently only about 40km, should be extended to 60 - 90km by integrating the neighbouring private and public expressways. In this way, operation costs can be saved by integrating the operation and maintenance systems, facilities and equipment, and jointly outsourcing common needs.

TABLE 4: Operation method for integrated government-invested and private-invested expressways (MLTM 2010)

Integrated routes	Length (km)	Regional Office in Charge
Busan-Ulsan (47.2) + Gyeongbu Exp (29.4)+ Ulsan Exp (14.3)	90.9	Ulsan Office
Oksan-Osan (12.1) + Gyeongbu Exp (55.5)	67.6	Cheonan Office
Osan-Gwangju (29.7) + Gyeongbu Exp (55.6)	85.3	Suwon Office
Gongju- Cheongwon (20.1) + Daejeon-Dangjin (78.6)	98.7	Gongju Office
Anyang-Seongnam (21.9) + 2nd Gyeongin (16.9) + Seohaean line (14.6) + Seoul Ring Road (19.9)	73.2	Siheung Office
Incheon-Gimpo (28.5) + Gyeongin (23.9) + Siheung-Ilsan (24.8)	77.2	Incheon Office
Busan New port 2nd back road (15.3) + Namhae line (80.1)	95.4	Changwon Office

OPERATION MODELS OF EXPRESSWAYS OPERATED BY KEC AND PRIVATE COMPANIES

Selecting the Target for Comparing the Operation Models

When comparing the length of expressways operated by the KEC and private operators, their distance and characteristics must be similar in order to guarantee credibility. As explained earlier, the KEC is responsible for the maintenance of three routes (Seoul-Chuncheon, Seo Suwon-Pyeongtaek, Busan-Ulsan), and the comparison targets of private operators are seven routes, among which three routes, the Cheonan-Nonsan, the Daegu-Busan, and the Seoul Ring Road (Ilsan-Toegyewon), appear to be similar in terms of characteristics and length with the three routes operated by the KEC. They were selected to be comparison targets as shown in Table 5.

Other expressways that have shorter lengths or different characteristics were excluded from comparison. The Yongin-Seoul Expressway was excluded because of its short length of 31km, and the Incheon Bridge and the New Airport Highway routes were also excluded because they exist for the three bridges, Incheon, Yeongjong Grand, and Banghwa, and thus, have different characteristics from private expressways managed by the KEC. As a result, the comparison targets were limited to the Cheonan-Nonsan, the Daegu-Busan, and the Seoul Ring Road. Also, the Pyeongtaek-Siheung Expressway was excluded as it was newly opened in 2013 and as yet lacks sufficient data.

TABLE 5: Private expressways for comparison with expressways managed by KEC (KEC 2012)

	Average	Cheonan-Nonsan	Daegu-Busan	Seoul Ring Road
Length (km)	47.3	80.96	82.05	36.30
Converted length (km)	56.2	81.0	82.1	58.6
Serviced since	-	Dec 2002	Jan 2006	Dec 2007

Comparison of Operation and Maintenance Models

Apparently, the overall work process of the expressways managed by the KEC and the three expressways managed by private operators are similar. With regards to the organizational structure, the expressway directly operated by private operators consists of Management Support Team, Operation Support Team, Road Maintenance Team, Traffic Support Team, and Customer Support Team as shown in Figure 1. The works based on the organizational structure are similar to the KEC. However, the outsourcing process shows slight differences as shown in Table 6.

FIGURE 1: Organization for managing private expressways and KEC

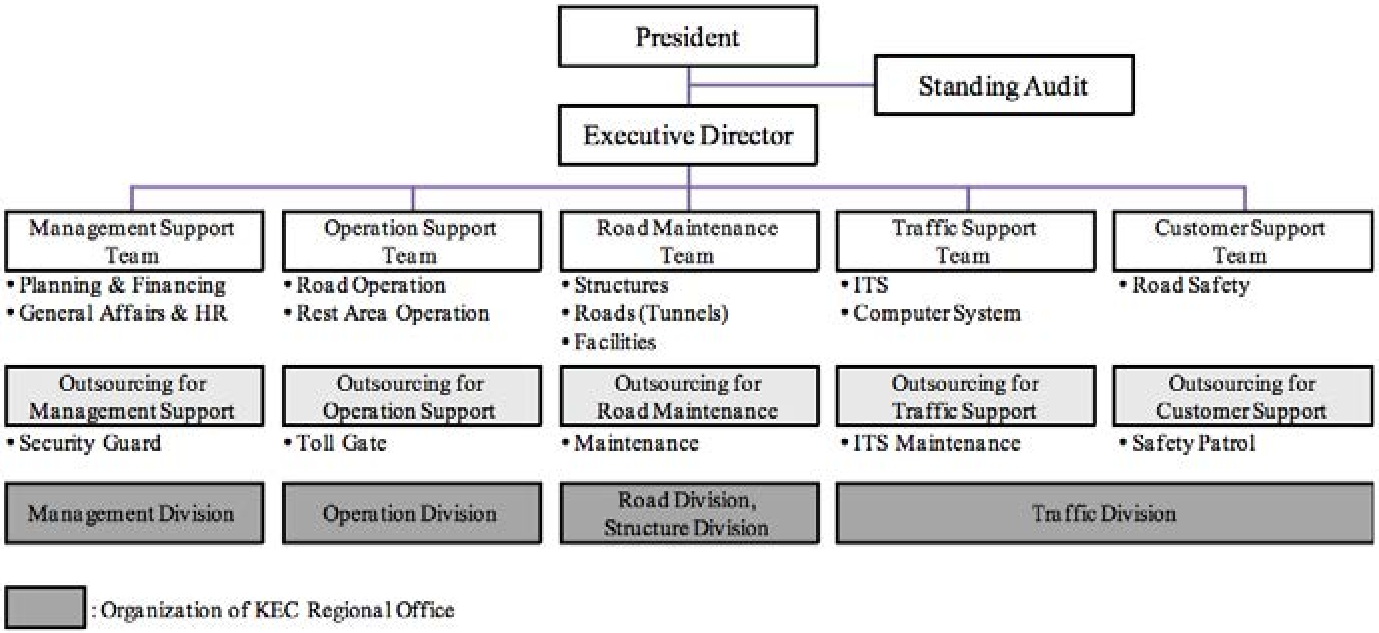


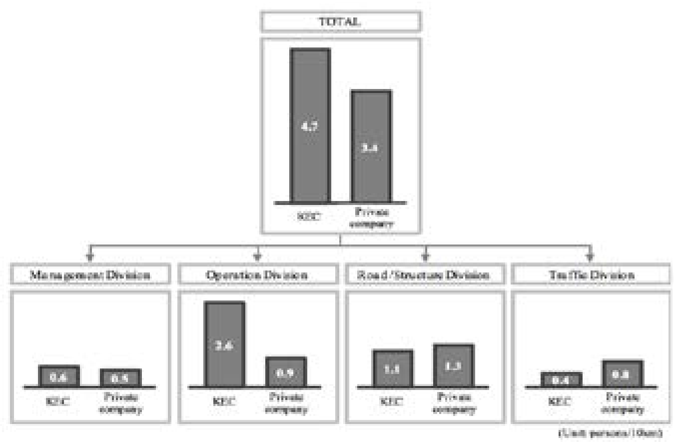
TABLE 6: Work process method of KEC and private expressways (KEC, 2012)

	KEC	Cheonan-Nonsan	Daegu-Busan	Seoul Ring Road
General maintenance	partly outsourced	directly managed	outsourced	outsourced
Traffic monitor	directly managed	outsourced	outsourced	outsourced
Structure inspection	directly managed	outsourced	outsourced	outsourced
Regular patrol	outsourced	outsourced	outsourced	outsourced
Repair & maintenance	outsourced	outsourced	outsourced	outsourced

As shown in Table 6, the KEC directly manages general maintenance, traffic monitoring and structure inspection which may directly affect expressway users. It outsources regular patrol and repair & maintenance. To save operation costs, private operators outsource most works except for administrative tasks. However, the Cheonan-Nonsan Expressway takes charge of general maintenance because manpower supply is limited in the region.

The number of personnel working for the KEC and for the three private expressways according to the "Establishment of Standard Model for Management Office of Private Expressways (KEC, 2012)" is shown in Figure 2. The total number of personnel per 10km at the KEC is approximately 1.3 higher than for private operators. For each department, the KEC has more management (0.1 person) and operation (1.7 person) personnel, and fewer road/structure (0.2 person) and traffic (0.4 person) personnel. Three departments, except operation, show that the KEC and the three private expressways have a similar number of personnel, or the KEC has fewer personnel. This is because the KEC integrated its systems with public highways except for the operation division. To save the general operation costs, the KEC must reduce the number of personnel in operation division.

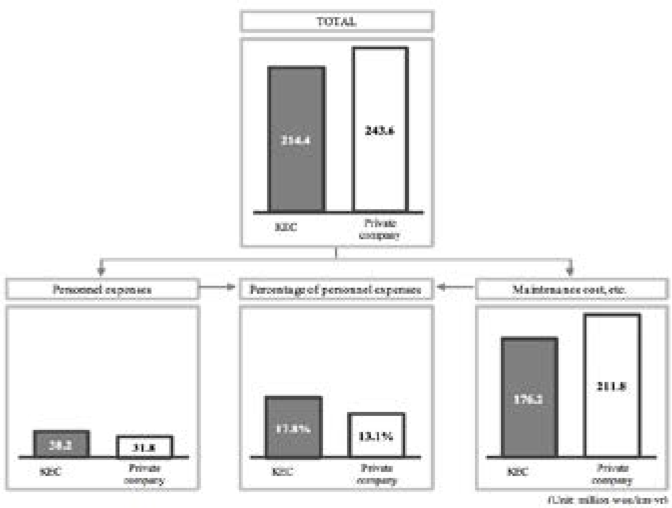
FIGURE 2: Number of staffs at KEC and private company (KEC, 2012)



Regarding the operation costs, general maintenance costs consist of personnel expenses and maintenance costs. Personnel expenses include payroll costs and other employee benefits of personnel necessary for operation and maintenance. Maintenance costs include those costs used to manage expressways and reinvestment costs used to replace facilities.

The Establishment of a Standard Model for the Maintenance Office of Private Expressways (KEC, 2012) compared the operation costs of the KEC and three private expressways of private operators, and the results are as shown in Figure 3. The operation cost per km is KRW 214 million for the KEC and KRW 244 million for private operators. Private operators spend approximately KRW 30 million per km more than the KEC. The personnel expenses are KRW 38 million for the KEC and KRW 32 million for private operators, which means the KEC spends approximately KRW 6 million per km more. The maintenance costs are KRW 176 million for the KEC and KRW 212 million for private operators, which means the private operators' costs are approximately KRW 36 million more than the KEC.

FIGURE 3: Operation cost at KEC and private company (KEC, 2012)



MEASURES TO IMPROVE THE MAINTENANCE OPERATION MODELS OF PRIVATE EXPRESSWAYS

As can be seen from the above examination, there is no significant difference in the maintenance work process and organizational structures of private expressways. There is some difference in terms of outsourcing, but this is due to the difference in the characteristics of public interest-pursuing KEC and profit-seeking private operators. In order to improve cost-efficiency, the KEC may consider the outsourcing of some areas that will not hinder the security of the public interest. However, the KEC is a public organization following government legislation, and thus it cannot bid and sign contracts at competitive prices compared to private operators. It may cause difficulties in ensuring cost-efficiency from outsourcing like private operators.

Based on the comparison of operation models, this study proposes improvement measures including the effective management of personnel at tollgate office, expanding outsourcing, and increasing profitability.

Effective Management of Personnel at Toll Gate Office

The KEC is more efficient in the organization and management of personnel compared to private operators, except with regard to operation, in which area it must seek improvement. The KEC has a comparatively higher number of office management personnel for the private expressways, which it operates, compared to private operators. The number of personnel per 10km did not incorporate the number of tollgate offices, therefore making it difficult for direct comparison. When the number of management personnel was recalculated based on the number of toll gate offices, there were approximately 2 times more personnel for expressways managed by KEC compared to expressways managed by private operators, as can be seen in Table 7.

TABLE 7: Number of staff per tollgate office

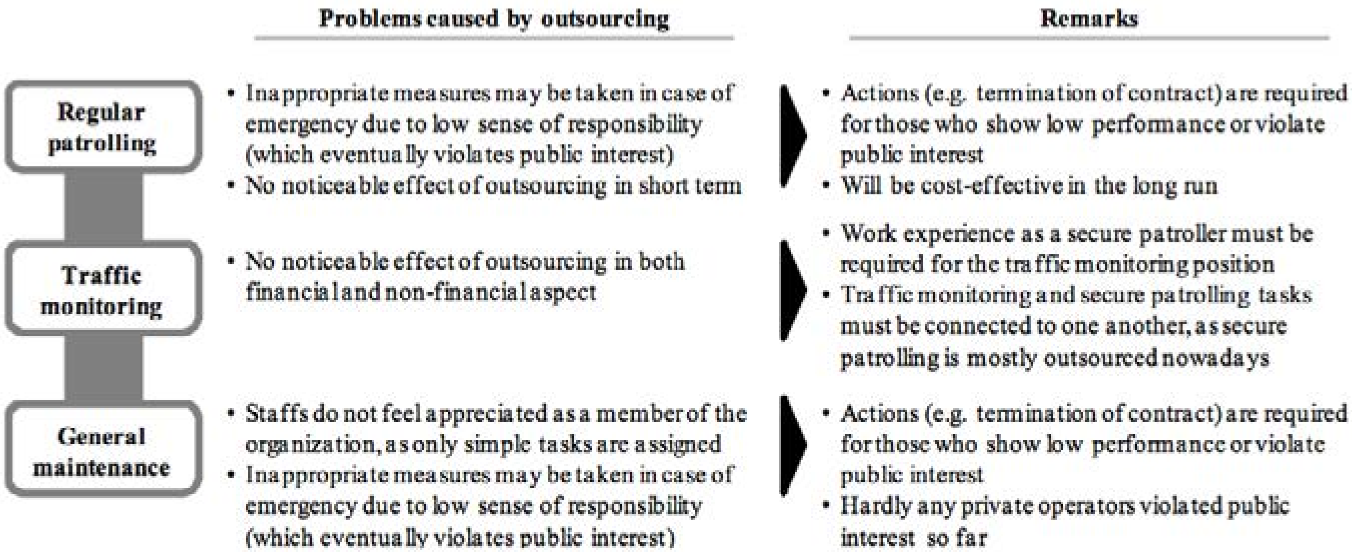
	Expressways managed by private operators	Expressways managed by KEC	Remarks
No. of staff per office	0.9	1.9	2.1 times
Management Personnel	20	44	
No. of toll gate offices	23	23	–

It may be concluded that the KEC's operation costs are lower, thus more efficient, than other private operators. However, since personnel cost is higher than other private operators, improvement measures must be found and applied for operation as mentioned before. The KEC plans to establish a staged personnel reduction plan and reduce the number of its personnel from 2 persons to 1 person per toll gate office, which will consequently enhance efficiency in terms of personnel management and cost reduction. Furthermore, the KEC must reduce the number of management personnel from 1 to 0.5 by integrating two tollgate offices, so that the number will be adjusted to the level of other private operators.

Expansion of Outsourcing

Taking account of private expressways operated by private operators, it is possible for the KEC to partially outsource works that are directly performed by the corporation on private expressways. It is also judged that it is appropriate to initially undertake a pilot project and expand it in the long term. Works that may be eligible for outsourcing are patrolling, traffic monitoring, and general maintenance, as shown in cases of private expressways of private operators. However, as described in Figure 4, any possible violation of public interests must be sufficiently considered before deciding on the applicability.

FIGURE 4: Problems caused by outsourcing



Increase of Profitability and Saving on Costs

The major purpose of expressways is to provide transport routes to vehicles, but utilizing expressway assets can also make profits. Currently, expressways are making profits with their side businesses, such as rest areas and gas stations, and are able to explore additional profit models in diverse areas, which to some degree will offset the operation costs. The KEC has applied or will apply several side business models, such as developing abandoned roads, and a whole new concept of integrated facilities at rest areas to replace the old type of resting facilities. If automated cameras are used for toll collection, significant costs can be saved on toll collectors or booth installation sites, which will no longer be needed. Efforts must be made to discover ways to create additional profits and save on costs by using IT. When contracting with private operators and including articles regarding an increase in profits and cost saving, such conditions must be explicitly stated in the agreements or negotiated with private operators so that they will not affect the operation costs of the KEC.

CONCLUSION

A total of 10 privately funded expressways are currently in operation and will increase to 24. Problems such as user inconvenience, congestion, and increase in the operational costs are on the rise as private expressways collect tolls and perform maintenance for each route within the short average length of mere 39km. The government, with the aim of resolving such problems, established the Measures for the Integrated Operation of Private Expressways (MLTM, 2010), and promoted the integrated operation of two or three short-distance private expressways so as to save the maintenance costs through economies of scale and the improve customer convenience through the establishment of an integrated toll collection system.

The three private expressways currently operated by the KEC and other three private expressways with similar characteristics and lengths were compared in terms of the operation and personnel costs. The necessary steps that the KEC must take in order to save budgets of routes in service are as follows:

- Private expressways operated by KEC have a higher proportion of personnel cost than private expressways directly operated by private operators. Therefore, for efficient operation, the KEC shall review and apply a reduction of tollgate office personnel.
- To save on maintenance costs, the KEC shall review the possibility of additional outsourcing that do not conflict with public interests.
- To increase profitability and save costs, the KEC shall find and apply diverse profit models, such as developing abandoned roads.

REFERENCES

1. Board of Audit and Inspection of Korea (2011), Cheonan-Nonsan, Daegu-Busan, Seoul Ring Road Expressway Audit Report
2. KEC (2011), Detailed regulation for the organization
3. KEC (2012), Establishment of Standard Model for Management Office of Private Expressways
4. KEC (2014), Expressway Work Statistics
5. Ministry of Land, Transport and Maritime Affairs of Korea (2009), A Study on Integrated Management System for Private Expressways
6. Ministry of Land, Transport and Maritime Affairs of Korea (2010), Measures for the Integrated Operation of Private Expressways
7. Ministry of Land, Transport and Maritime Affairs of Korea (2011), Basic Plan for Road Modification II
8. Ministry of Strategy and Finance (2011), National Financial Management Plan 2011 - 2016
9. Cheonan-Nonsan Expressway, http://www.cneway.co.kr
10. New Daegu-Busan Expressway, http://www.dbeway.co.kr
11. Seoul Expressway, http://www.seoulbeltway.co.kr

ANALYZING TOLL ROAD SERVICE QUALITY FROM A ROAD USER PERSPECTIVE: CASE STUDY OF TOLL ROAD IN JAVA

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ABSTRACT

Many researchers believe that toll road performance should be measured using two main indicators, physical condition and travel time. Though, there are more services perceived by customer while they are using toll road service. This paper will focus on proposing service quality element to the road users in order to enhance their decision to use toll road and their satisfaction of using it. Using SERVQUAL methods and Importance Performance Analysis, authors reveal 8 services attributes, which greatly affect customers' satisfaction, most of them related to reliability and responsiveness dimension.

INTRODUCTION

Mobility plays an important role in urban and rural economy. In this decade, it continues to grow as the development of a nation, especially because of economic growth. To fulfill the demand of mobility, the needs of new road provision emerge as a solution, including toll road provision. The goal of toll road provision is to distribute development in all area of Indonesia. Efficiency of development is necessary to boost economic growth, not only for urban area, but also in rural area.

In Indonesia, toll road provision is the obligation of national government. To maintain and accelerate the provision of infrastructure including toll road, government adopt build operate transfer (BOT) public private partnership (PPP) concept, where private company where private sector is authorized to design, fund, build and operate toll roads in accordance with the concession agreement with the government at the time agreed upon ownership of toll road assets will be handed over to the government (Levy, 1996). However, lack of quality control by government cause the operator keeps providing unsatisfactory service to users. In addition, both government and operator give small attention to users' perspective. So, the perspective of service quality level between government, operator, and user may not match (Zeithaml et al, 1990).

Many researches focus on travel time benefit as the main factor, which influence the decision to use toll road (Jou et al, 2012). However, The development suggests that the user's ability/willingness to pay is not the only determining factor in people 's decision to use the toll road. Highway users continue to use the toll road even though there are no time saving benefits gained. It is estimated that there are other factors that affect decisions such as the use of highway service quality (service quality). The study develops toll road service quality concept in Indonesia based on road user perspective. A similar study based on quality of service is commonly found in other modes such as rail, airline, public transport (Eboli & Mazzulla, 2008). This paper will focus on proposing service quality element to the road users in order to enhance their decision to use toll road and their satisfaction of using it.

LITERATURE REVIEW ON SERVICE QUALITY AND CUSTOMER SATISFACTION

Service users generally have an initial perception of a thing that is offered in the form of products or services. The perception of an individual's initial response will be a good thing from the standpoint of positive and negative. Associated with quality of service, fulfillment of initial perceptions of the individual are very important and influential to a value of quality of service. According Tjiptono (2005), the quality of service defines the dynamic state associated with products, services, human resources, processes and environments that meet or exceed expectations.

Quality of service is a collection of some of the public perceptions of a form of service. Another definition, service quality is a form of attitude representing the overall evaluation of long-term (eg Cronin and Taylor, 1994). Service quality is measured on the perceptions and expectations of service users to shape the quality of service that can be identified by considering the interests and user satisfaction (Eboli & Mazzulla, 2008). Customer satisfaction is a response to consumer demand, which is a consideration for a product or service in providing enjoyable consumption levels. While Kotler (1995) defines customer satisfaction as the level of one's feelings after comparing the performance or results that he felt compared to expectations.

Gronroos model was the early conceptualization of service quality, which defined service quality by three elements, namely technical quality (outcome), functional quality (process of delivery the service), and Image (Gronroos, 1984). Later, this model was developed by several authors to propose their own service quality model (Rust & Oliver, 1994; Parasuraman et al, 1988; Dabholkar et al, 1996; Brady & Cronin, 2001). Even some other model have been proposed, SERVQUAL Model proposed by Parasumaraman et al (1985) is the model often used by authors to measure service quality. Parasuraman et al (1990) mentioned five dimensions of SERVQUAL, known as RATER:

- Reliability: ability of providers to perform and deliver the promised services accurately and reliably.
- Assurance: or guarantee of knowledge, skill, and ability of service providers for creation of a trust.
- Tangible or physical evidence: a manifestation of the existence of a service provider to the user, this can include physical facilities, infrastructure and equipment.
- Empathy: provision of individual care and attention to customers
- Responsiveness: The willingness to help customers and provide prompt service

Zethaml et al (1990) adding measurement of disconfirmation paradigm to complete this model, by measuring gap or difference between expected service and perceived service by the user. Disconfirmation paradigm stated that if the service perceived by user is less than expected, mean the satisfaction is not met, otherwise if the service perceived by the user equal or greater than expected, the satisfaction is met (Jain & Gupta, 2004). Furthermore, This theory identifies five gaps, which is: (1) The gap between customer expectation – perception of management; (2) The gap between management perception-perception of service quality; (3) the gap between service quality specifications and actual service quality; (4) The gap between the way the ministry of external communication about this service; (5) The gap between expectation and perception of the services.

SERVQUAL model has widely used to measure service quality in service sector, e.g. education service (Akhlagi et al, 2012), banking service (Ariff et al, 2013; Yousapronpaiboon, 2014), and health care service (Purcarea et al, 2013). Moreover, this model was also used in several public transport research e.g. bus service, train service, airport and airline service, although some of them have modified the dimension of SERVQUAL (Pabendinskaite & Akstinaite, 2014; Mustafa et al, 2005; Aydin & Yildirim, 2012; Randheer et al, 2012). Other authors also tried to measure user satisfaction based on service quality by defining different variable from RATER dimensions (Shabaan & Khalil, 2013; Maravuda & Bellamkonda, 2013; Eboli & Mazulla 2006, 2007, 2008; Geetika, 2010, Litman, 2008).

Road, including toll road, is considered as a (public) goods, not a service. Performance of toll road generally defined based on road provision and preservation, added with outcome factors such as economy, environment, traffic, etc. (Humplick & Peterson, 1994; Hartanto & Susilo, 2001). While the most important factor is travel time benefit and traffic condition (Senbil & Kitamura, 2004; Jay et al, 2011; Susilawati et al 2008; Sakai et al, 2011). These indicators generally can be diagnosed and measured by operator using specific tools and methods, with slight involvement of customers' viewpoints. In addition, many researchers believe that travel time, besides physical preservation, is the mostly affecting to customer satisfaction rather than other factor.

In this paper, authors try to think oppositely, that toll road is a service. Customers' activities while using toll road should also be defined as toll road service quality. Customers are involved and inseparable in the value-creating process in service sector as a co-creator role (Gronroos, 2011). Customers' perception and expectation can be a consideration to operator to define level of service quality delivered.

RESEARCH METHODOLOGY

This study conducted in 11 toll roads in Java Island, Indonesia, consisting 4 urban toll roads, and 7 inter-urban toll roads, To collect primary data, two thousand questionnaires were distributed to toll road users, with different number of questionnaire for each toll roads, based on its traffic volume.

The questionnaire asked respondents about quality of toll road service attributes, both expectation (importance level) and perceived (performance level). The evaluation of these level ranked 1 to 5 on Linkert Scale with "1 = not important/ not satisfied, 2 = least important/least satisfied, 3 = fair importance/fair satisfied, 4 = important/satisfied, 5 = very important/very satisfied."

Many approaches to measure service quality and satisfaction level, including the methods of Importance Performance Analysis (IPA). IPA is a method proposed by Martilla & James (1977) to measure performance of a product or service using users' satisfaction level and expectation level. Furthermore, this tool not only measure performance, but also provides a strategy to improve service quality. IPA forms a matrix with importance value as the x-axis and performance value as the y-axis. IPA Matrix is divided into four quadrant: (1) High importance – high performance, called "keep up the good works", (2) High importance – low performance, called "concentrated here", (3) Low importance – low performance, called "low priority", and (4) Low importance – high performance, called "possible overkill".

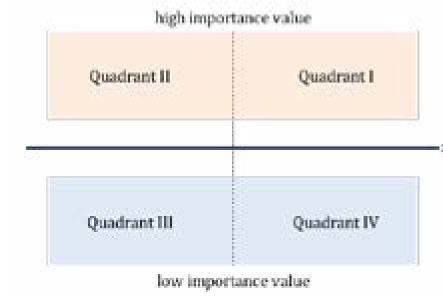
Using Importance Performance Analysis matrix, this paper assess service quality focused on its importance value (quadrant 1 and quadrant 2), with additional information of its performance level. Service attributes categorized as an important attributes when the importance value is greater than importance value mean (x axis).

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n} \quad \text{.............................} \quad (1)$$

$\overline{X\iota}$ = mean of importance value

N = number of respondent

FIGURE 1: Importance Performance Analysis



SOURCE: Adapted from Martilla & James (1977)

RESULT AND DISCUSSION

From the questionnaire data, the trip characteristics of toll roads user are identified as it can be seen in table 1. From this table, can be seen that most of respondent use toll road for work/business based trip and because it is have travel time benefit compared to non-toll road. The paradigm that main service of toll road is to reduce travel time have been embedded by most traveler, which consistent with some authors who considered travel time benefit as main indicator to measure road performance, especially toll road.

TABLE 1: Trip Characteristic

	Total	Urban Toll Road	Inter Urban Toll Road
Types of vehicle			
Passenger	82%	90%	79%
Freight	18%	10%	21%
Frequency			
4 times a week or more	41%	71%	38%
2-3 times a week	32%	17%	31%
1 time a week or less	27%	12%	31%
Purpose			
Work/business	78%	90%	78%
Leisure	6%	3%	7%
Others	16%	7%	15%
Reason			
Time benefit	89%	91%	90%
Safety benefit	2%	2%	2%
Comfort benefit	5%	4%	5%
Other reason	4%	3%	3%

SOURCE: Data analysis (2014)

Table 2 shows the result of average importance value and performance value based on users' perspective for each toll road attributes. However, users' perception defined all toll road attributes to be an important attributes (no attributes have importance value lower than 4), with "no traffic congestion", "riding safety", and "smoothness of road surface" as the 3 highest importance value. However, customers feel all of services were delivered below their expectation level.

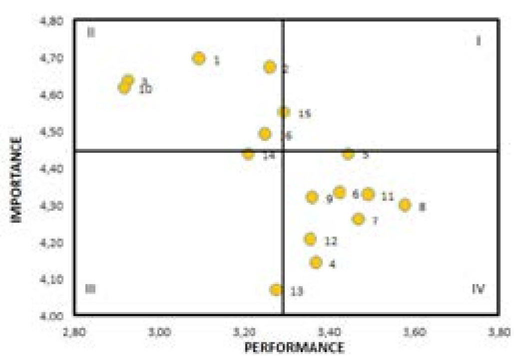
TABLE 2: Importance Performance Value of Toll Road in Java

No	Attributes	Importance Value	Performance Value	Gap
1	No traffic congestion	4.70	3.10	-1.60
2	Riding safety	4.68	3.26	-1.41
3	Smoothness of road surface	4.64	2.93	-1.71
4	Accuracy of information given	4.14	3.37	-0.77
5	Security from crime	4.44	3.45	-0.99
6	Toll gates operator services	4.33	3.43	-0.91
7	Friendly toll gates operator	4.26	3.47	-0.79
8	Honest toll gates operator	4.30	3.58	-0.72
9	Toll gates facilities	4.32	3.36	-0.96
10	Lighting	4.62	2.92	-1.70
11	Traffic sign and information board	4.33	3.49	-0.83
12	Facilities of rest area	4.21	3.36	-0.85
13	Call center service	4.07	3.28	-0.79
14	Fast response of emergency unit	4.44	3.21	-1.23
15	Accident handling	4.55	3.30	-1.26
16	Responsiveness in road preservation	4.49	3.25	-1.24
	Grand Mean	**4.41**	**3.30**	

SOURCE: Data analysis (2014)

Based on table 2, IPA matrix was created. Figure 1 shows that there are 8 attributes plotted in quadrant 1 and 2, which have importance value greater than x-axis. The attributes which need to be priority (1) no traffic congestion, (2) riding safety, (3) smoothness of road surface, (5) security from crime, (10) road lightings, (14) fast response of emergency unit, (15) accident handling, and (16) road preservation. For additional information, quadrant 1 only consist of (5) security from crime, while rest of them have performance value below y-axis (categorized as quadrant 2), It means, most of them are provided with inacceptable performance, and need to be concerned by toll road operator to improve its level of service.

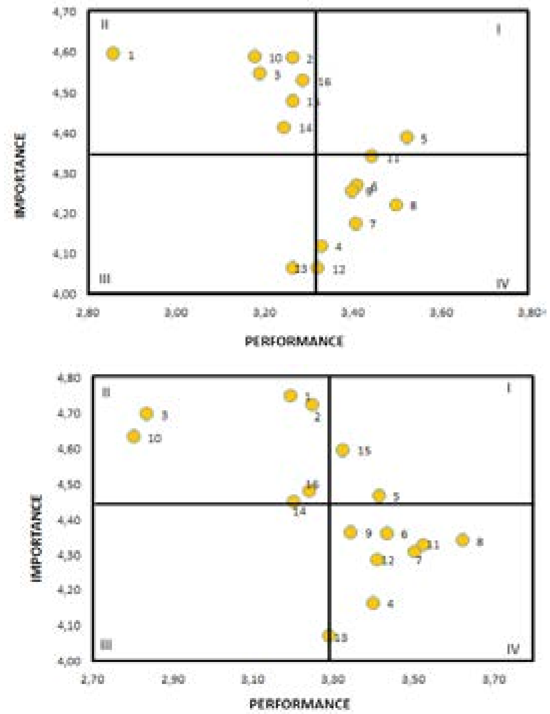
FIGURE 2: Importance-Performance Analysis Total Respondent



SOURCE: Data analysis (2014)

Figure 3 illustrates comparison of service quality importance value between urban toll roads and inter urban toll road. Even both of them have different value of importance and performance, it consist same attributes.

FIGURE 3: IPA Matrix Urban – Inter Urban Toll Road



SOURCE: Data analysis (2014)

CONCLUSION

Based on IPA methods, operator can define which attributes should be on priority to maintain user satisfaction. Toll road users have high expectation on every service provided by operator. However, for efficiency purposed, operator should focused to the most important attributes first, namely no traffic congestion, riding safety, smoothness of road surface, security from crime, road lightings, fast response of emergency unit, accident handling, and road preservation. Based on this fact, can be said that users are more concerned about services perceived while they are driving (reliability of toll road) and how the operator response for emergency situation (responsiveness of toll road operator). In addition, there are no different between urban toll road and inter urban toll road. Government can establish general standard for both urban and inter urban toll road. While the study more concerned on importance value of each service attributes, it also found that most of them delivered with unacceptable performance.

Beside the function of this methods to define what attributes should be in priority, this method too much rely on user perception, which have high bias on its value. As it stated before, the value of importance level stated by users for each attributes are very high, and it affect the x-axis, resulting important attributes categorized as unimportant attributes. However, this tool can help operator to understand the needs of customer and invite them to be part of service creation process.

REFERENCES

1. Akhlaghi, E., Amini, S., Akhlaghi, H. (2012). Evaluating Educational Service Quality in Technical and Vocational Colleges using SERVQUAL Model. Procedia - Social and Behavioral Sciences, Volume 46, 2012, Pages 5285-5289.
2. Archana, R. & Subha, M. V. (2012). A Study On Service Quality And Passenger Satisfaction On Indian Airlines. International Journal of Multidisciplinary Research Vol. 2 Issue 2.
3. Ariff, M. S., Yuna, L. O., Zakuan, N. (2013). The Impacts of Service Quality and Customer Satisfaction on Customer Loyalty in Internet Banking. Procedia - Social and Behavioral Sciences Volume 81, 28 June 2013, Pages 469–473.
4. Aydin, K., & Yildirim, S. (2012). The Measurement of Service Quality with Servqual for Different Domesitic Airline Firms in Turkey. Serbian Journal of Management 7 (2): 219 – 230.
5. Cronin, J. J. & Taylor, S. A. (1994). SERVPERF Versus SERVQUAL: Reconciling Performance-Based and Perceptions-Minus-Expectations Measurement of Service Quality. Journal of Marketing Vol. 58, No.1:125-131.
6. Dabholkar, P. A., Thorp, D. I., & Rentz, J. O. (1996) A Measure of Service Quality for Retail Stoes: Scale Development and Validation. Journal of the Academy of Marketing Science 24
7. Eboli, L. & Mazulla, G. (2008). Willingness to pay of public transport users for improvement in service quality. European Transport 38: 107-118.
8. Geetika, S. N. (2010). Determinants of Customer Satisfaction on Service Quality: A Study of Railway Platforms in India. Journal of Public Transportation, Vol. 13, No. 1, 2010.
9. Grönroos, C. (1984). A Service Quality Model and its Marketing Implications, European Journal of Marketing, Vol. 18 Iss: 4, pp.36 – 44.
10. Gronroos, C. (2011). Value Co-creation in Service Logic: A Critical Analysis. Marketing Theory 11: 279-301.
11. Hartanto, B. & Susilo, Y. O. (2001). Performance Indicators as a Measurement of Successful of Road Development. Proceedings of the Eastern Asia Society for Transportation Studies, Vol. 3, No. 1.
12. Humplick, F. & Peterson W.D.O. (1994). A Framework of Performance Indicators for Maneging Road Infrastructure and Pavemenh. 3d International Confrence, San Antonio Texas. P 22-26,Mei 1994
13. Jain, S.K., & Gupta, G. (2004). Measuring service quality: SERVQUAL vs SERVPERF Scales. VIKALPA, 29 (2), 25-37
14. Jou, R. C., Chiou, Y. C., Chen, K., Tan H. I. (2012) Freeway Drivers' Willingness to Pay For a Distance Based Toll Rate. Transportation Research Part A 46:549-559
15. Kotler, P.(1995). Manajemen Pemasaran. Penerbit Erlangga. Jakarta.
16. Levy, D. A. (1996) BOT and Public Procurement: A Conceptual Framework. Indiana International & Comparative Law Review Vol 7:1.
17. Litman, T. (2008). Valuing Transit Service Quality Improvement. Journal of Public Transportation, Vol. 11, No. 2, pp. 43-64.
18. Maravuda D. P. & Bellamkonda, R. S. (2013) The Effects of Demographic Variables on Railway Passenger Service Quality: Finding from Indian Railway Passenger Service through Rail Qual. International Journal of Advances in Management and Economics Vol 2.
19. Martilla J. A., & James, J. C. (1977) Importance Performance Analysis. Journalof Marketing vol 41, pp. 77-79.
20. Mazulla, G. & Eboli, L. (2006). A Service Quality experimental Measure for Public Transport. European Transport 34 (2006) : 42-53.
21. Mazulla, G. & Eboli, L. (2007). Service Quality Attributes Affecting Customer Satisfaction for Bus Transit. Journal of Public Transportation Vol. 10 No. 3.
22. Mustafa, A., Jia-Pei, F., Siaw-Peng, L. (2005) The Evaluation of Airline Service Quality Using The Analytic Hierarchy Process. International Conference on Tourism Development 2005.

23. Nishio T., Tsukada Y., Oba T., Ohno M. (2006). Outcome Oriented Performance Management of Road Administration in Japan. Transportation Research Board 85th Annual Meeting.
24. Pabedinskaite A. & Akstinaite V. (2014) Assessment of The Airport Service Quality. Procedia - Social and Behavioral Sciences 110 (2014) 398 – 409.
25. Parasuraman (1990). An Empirical Examination of Relationships in an Extended Service Quality Model. Marketing Science Institute, Cambridge, MA.
26. Parasuraman (1988). SERVQUAL: A Multiple-Item Scale for Measuring Consumer Perceptions of Service Quality. Journal of Retailing Vol 64 No 1.
27. Purcărea V. L., Gheorghe I. R., Petrescu C. M. (2013). The Assessment of Perceived Service Quality of Public Health Care Services in Romania Using the SERVQUAL Scale. Procedia Economics and Finance Volume 6, 2013, Pages 573–585.
28. Randheer K., AL-Motawa A. A., Vijay. P. J. (2012) Measuring Commuters' Perception on Service Quality Using SERVQUAL in Public Transportation. International Journal of Marketing Studies Vol. 3, No. 1.
29. Sakai T., Yamada-Kawai K., Matsumoto H., Uchida T. (2011) New Measure of the Level of Service for Basic Expressway Segments Incorporating Customer Satisfaction. Procedia Social and Behavioral Sciences 16: 57–68.
30. Senbil, M. & Kitamura R., (2004). Willingness To Pay For Expressway. EES 2004: Experiments in Economic Science – New Approaches to Solving Real-World Problems.
31. Shabaan K. & Khalil R. F. (2013) Investigating the Customer Satisfaction of the Bus Service in Qatar. rocedia - Social and Behavioral Sciences, Volume 104, Pages 865-874.
32. Susilawati, Taylor, M., Somenahalli, S. (2008) Travel Time Variability and Reliability (the south road corridor study case). Conference of Australia Institute Transport Research CAITR 2008.
33. Tjiptono, F. (2005). Pemasaran Jasa. Bayu Media Publisher, Malang.
34. Yousapronpaiboon K. (2014). SERVQUAL: Measuring Higher Education Service Quality in Thailand. Procedia Social and Behavioral Sciences Volume 116, 21 February 2014, Pages 1088–1095
35. Zaller, J. E. (1992). The Nature and Origins of Mass Opinion (Cambridge Studies in Public Opinion and Political Psychology). Cambridge University Press.
36. Zeithaml, V. A., Bitner, M. J., & Gremler, D. D. (2006). Service marketing: Integrating customer focus across the firm. (4th ed.). New York, NY: McGraw - Hill/Irwin.
37. Zeithaml, V. A., Parasuraman A., Berry, L. L. (1990). Delivering Quality Service: Balancing Customer Perceptions and Expectations. Free Press, New York, NY.
38. Zeithaml, V. A., Parasuraman, A. and Malhotra, A. (2000). A Conceptual Framework for Understanding E-service Quality: Implications for Future Research and Managerial Practice. Marketing Science Institute Working Paper Series, Report No. 00-115.
39. Zeitsman J., & Ramani T. (2006). Guidebook for Sustainability Performance Measurement for Transportation Agencies. NCHRP Report 708.

EFFICIENCY OF INNOVATIVE PROCUREMENT MODELS A FRONTIER ANALYSIS OF U.S. HIGHWAY P3s

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ABSTRACT

Public-Private Partnerships (P3s) have become a popular procurement mechanism for infrastructure facilities. Economic theory suggests potential efficiencies that P3s could provide when investing in capital assets. P3s also raise concerns about institutional and economic risks. Efficient delivery of infrastructure projects with P3 arrangements has not yet been fully investigated empirically. This study employs Data Envelopment Analysis (DEA) to analyze the efficiency of P3 projects, focusing on tolled and non-tolled motorway capacity expansion projects. Findings from the analysis provide potentially useful insights into the benefits and potential risks relevant to states in the United States and elsewhere. The results of the analysis pointed to a number of issues with the data used, which were collected from various sources with the potential of over-simplification. The analysis suggested that, while the methodological approach may have demonstrated its potential as a useful technique to draw policy insights, there are several challenges that must be overcome.

INTRODUCTION

Public-Private Partnerships (P3s) have become a popular procurement mechanism to deliver infrastructure facilities such as roads, bridges, and tunnels. In the United States (U.S.), a few leading states have been aggressively debating and implementing P3 policies and projects to address unmet needs of infrastructure and fiscal constraints on the public sector (1). Economic theory suggests potential efficiencies that P3s could provide in infrastructure investment (2). At the same time, governments have demonstrated their interests in P3s to overcome their financial constraints for infrastructure delivery (3). As a result, the financing aspects of P3s receive considerable attention. Yet, P3s also raise issues and concerns about institutional and economic risks (4). Previous studies suggest that external financing for P3 projects (e.g. private equity, subsidized debt) have both positive and negative effect on the projects in terms of project companies' commitments to achieve expected performances (5).

In the contexts of infrastructure investment, decision-makers commonly face considerable uncertainties that require skillsets to use appropriate methods to evaluate alternatives, which they often lack (6). They are also limited in terms of quality information that aid conducting appropriate analysis. Traub argued that information used for addressing complex problems is by nature "partial, contaminated, and it costs (7)." Empirical investigations to support the notion of efficient delivery of infrastructure projects with P3 arrangements have been limited to mostly European contexts to date, and results have been limited at best (8).

Provided the limitations for empirical investigations on P3s, the objective of this study is to demonstrate to what extent readily available P3 project data can generate meaningful insights on the efficiency of the procurement mechanism. The authors assembled data that are low-cost but could be highly contaminated and partial, and employed Data Envelopment Analysis (DEA) to measure efficiency frontier scores of Decision Making Units (DMUs). The authors estimated efficiency scores of tolled and non-tolled motorway capacity expansion projects with P3 contractual arrangements in the U.S. Relative (in) efficiencies of input variables are compared to analyze which project factors contributed to inefficiencies in delivering these facilities.

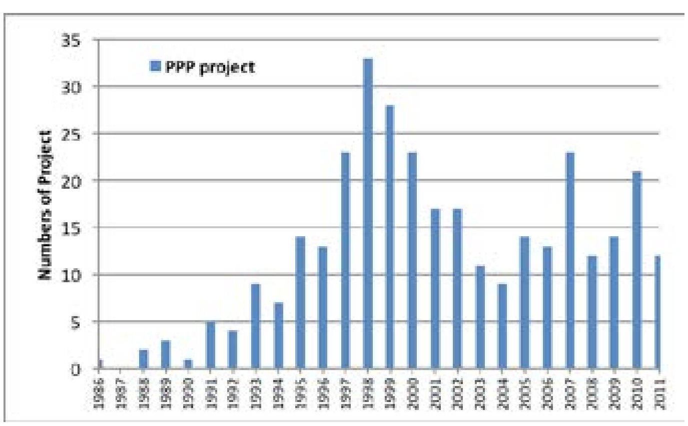
BACKGROUND

The origin of P3s as an infrastructure financing mechanism in the U.S. dates back to at least the nineteenth century: by then, P3s were already used to fund transportation systems (3). The Philadelphia and Lancaster Turnpike in Pennsylvania, which was chartered in 1792, can be considered as the first turnpike built under a P3 arrangement in the U.S. (9). Modern applications of P3s are broad and extensive. One of the apparent factors that motivate state and local governments to increase their reliance on P3 arrangements is to overcome severe fiscal constraints in addressing the dire infrastructure needs (10).

Figure 1 illustrates the changes in the numbers of non-military infrastructure projects of various sectors with P3 arrangements that reached financial close between 1986 and 2011. In 1998, the number of P3 projects reached its peak at 33. In spite of a decline that followed, the numbers begin to increase again in 2004. It should be noted that the figure is not weighted by project scale (11).

Economic discussions on P3s have principally evolved to understand their economic advantages and disadvantages (11). The dominant frameworks are incomplete contract theory and risk allocation, with additional consideration of the governmental accounting treatment of P3 financing and their macroeconomic implications (12). Scholars have paid attention to the cost saving and the potential for more effective management of project costs and risks.

FIGURE 1: Non-Military P3 Projects Underway or Completed in the U.S., 1986-2011 (Source: Public Works Financing)



Conventionally procured projects use "design-bid-build" model, where the government determines the project scope, designs the project, and hires separate contractors for each stage of the implementation. While this mechanism can ensure accountability of each project stage and achieve transparency, it may not be the most cost efficient approach. For example, when confronted with unexpected site conditions, the costs associated with the process to change the design specifications and reflect the changes on the field can be costly. In this mechanism, the public sector bears the risk of cost increases and project delays.

Design-build procurement evolved to remedy such design risks: by contracting both design and construction phases, change orders may considerably decrease. The bundling of project components could be further extended to incorporate the maintenance stage into the contract, with the hope that the cost efficiencies could also be further extended. By bundling the maintenance and/or operation stages of a project into a design-build contract, the P3 is expected to give incentive for the contractor to produce the project in a manner that minimizes the project's life-long costs, to the benefit of society.

ANALYTICAL FRAMEWORK

Data Envelopment Analysis (DEA) was introduced to estimate production frontier through the use of linear programming (34), (35), (36). It is a non-parametric approach that allows efficiency analysis of multiple inputs and/or multiple outputs of a production process, imposing minimum assumptions, with no need to specify a priori a functional form for empirical estimation (31), (37). The strengths of DEA motivated a number of studies of production efficiency, as reviewed briefly in the previous section.

The authors assumed input-oriented project delivery to minimize the input for a given level of output, since capacity expansion projects of highways tend to be first defined by state Departments of Transportation (DOTs) as part of their Long-Range Transportation Plans and then procurement mechanism is determined. This study follows some of previous DEA studies that employed input-oriented DEA that specify one input and multiple output variables (25).

In this framework, n decision making units (DMUs), which represent P3 motorway projects, use a vector of p inputs x to produce a vector of output y, and the efficiency score $\theta(x,y)$ is estimated by solving the following linear programming problem:

$$\text{Min } \theta \qquad (1)$$

$$\text{s.t. } \theta x \geq X\lambda \qquad (2)$$

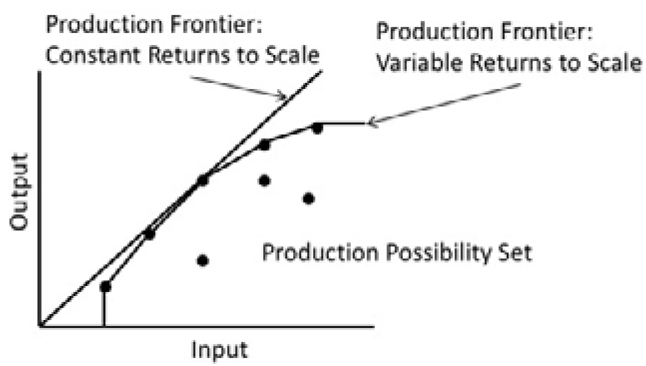
$$y \leq Y\lambda \qquad (3)$$

$$\lambda \geq 0 \qquad (4)$$

where $Y=[y_1,\dots,y_n]$ and $X=[x_1,\dots,x_n]$, while (x_i,y_i) $i=1,\dots,n$, which denotes the observed vectors of input and outputs. θ is a scalar and λ is a $n\times 1$vector of constants. This model assumes constant returns to scale (CRS) throughout the production set. To account for variable returns to scale (VRS), an additional constraint is included in the problem: $i\lambda=1$, which imposes a convexity condition.

Figure 2 graphically demonstrates a simple example of 1 input 1 output DEA model. DMUs are represented as black dots that are part of the production possibility set, for respective levels of input and output. The DMU on the DEA-CRS curve defines the production frontier, and the efficiency scores of other DMUs are obtained in relation to the production frontier curve. When convexity is imposed, more DMUs define the production frontier (DEA-VRS curve). As a result, as suggested by Seiford et al., DEA-VRS efficiency scores are generally higher than the DEA-CRS efficiency scores (38).

FIGURE 2: DEA Efficiency Estimates, CRS and VRS (36)



This study focuses on motorway projects as the Decision Making Units (DMUs) for the analysis. Project delivery is the production of these DMUs. The authors defined the DMUs as tolled or non-tolled motorway capacity expansion projects that have been delivered through Design-Build (DB), Design-Build-Finance (DBF), Design-Build-Maintain (DBM), or Design-Build-Finance-Operate-Maintain (DBFOM) contracts. These contract types involve considerable risk transfer from the traditional Design-Bid-Build (DBB) model, such as design, construction, and traffic risks. Operation & Maintain (O&M), Lease, and other contract types of P3s were excluded from the analysis, as the services provided through these P3 arrangements are substantially different. Figure 3 shows the locations of the DMUs. A number of projects are located in a few states with extensive records of P3 delivery (e.g. California, Florida, Texas, and Virginia). Most of the projects are in the states with P3s enabling legislations.

FIGURE 3: Greenfield P3 Motorway Projects included in the Analysis as DMUs (Source: Public Works Financing)

Because the number of DMUs is modest, the analysis is constrained regarding the number of variables that can be specified: the authors follow the insight that the minimum number of DMUs should be at least three times as the number of variables (39). In this model, the input is the project costs, and the output is the motorway project that is delivered. The authors followed previous studies of subnational governments, which specified the input as total expenditure and the output as the extent of various services provided, including road provision and maintenance (23), (24), (25), (37).

With limited data available, the authors selected the following variables to represent the production function of project delivery. The input variable is the projects' total cost at the financial close, in 2012 dollars ("costreal"). The output variables are: lane-mileage ("lanemileage"), the number of bridges ("bridge"), and the number of interchanges ("interchange") from the projects, at their financial close. The data of most of the DMUs were obtained from Public Works Financing P3 project database. The values were crosschecked with other sources, including the state DOTs, contractors and the FHWA Office of Innovative Project Delivery website. Table 1 summarizes the variables.

TABLE 1: Descriptive Statistics of the Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Costreal	37	631.6983	619.3702	40.1467	2292.16
Lane Mileage	37	106.8703	79.28476	20	396
Bridge	v	31.18919	31.72962	0	142
Interchange	37	7.743243	6.295525	0	27

RESULTS

The authors used the DEAP software package for the input-oriented DEA-CRS and DEA-VRS analysis (40). Table 2 presents the efficiency scores using DEA-CRS and DEA-VRS, Scale Efficiency, which is calculated by solving $\theta_{CRS}=\theta_{VRS}\times S.E.$ Generally, the DEA-CRS scores are referred to as the global technical efficiency, while the

DEA-VRS scores are interpreted as local pure technical efficiency (38).

Overall, it appears that the efficiency scores of many DMUs are extremely low values, compared to many other studies that employed DEA. Summary statistics of the estimates are presented on Table 2. The mean and standard deviation of the CRS technical efficiency were 0.5708 and 0.129, respectively. Table 3 summarizes the estimated scores. DMUs with the lowest CRS scores were: VA_I895 Pocahontas Parkway (0.129), CA_SR125 South Bay Expressway (0.187), VA_I495 Express Lanes (0.189), TX_SH601 Liberty Express (0.217), and TX_SH130 segment 1-4 (0.217).

TABLE 2: Frequency Distribution of DEA Technical Efficiencies of U.S. Highways

	DEA Technical Efficiency Scores		
	Freq.	Percent	Cum.
<0.199	1	1.89	1.89
0.200-0.299	1	1.89	3.77
0.300-0.399	4	7.55	11.32
0.400-0.499	14	26.42	37.74
0.500-0.599	5	9.43	47.17
0.600-0.699	12	22.64	69.81
0.700-0.799	7	13.21	83.02
0.800-0.899	5	9.43	92.45
0.900-0.999	1	1.89	94.34
1	3	5.66	100
Total	**53**	**100**	

The DEA-VRS scores of many DMUs resulted in low values. The mean and standard deviation of the VRS technical efficiency score were 0.704 and 0.269, respectively. The DMUs with the lowest efficiency scores were: VA_I895 Pocahontas Parkway (0.141), CA_SR125 South Bay Expressway (0.187), TX_SH601 Liberty Express (0.242), VA_I495 Express Lanes (0.256), and VA_Dulles Greenway (0.256).

Scale Efficiency provides insights on operational efficiencies of DMUs. For example, a DMU with low DEA-VRS score with low DEA-CRS score would result in a high Scale Efficiency score, implying low efficiency of operation due to environmental constraints. VA_I95 Pocahontas Parkway can be an example, with its SE score of 1.000. AZ_I17, NC_US64, NM_US70 and SC_Southern Connector had 1.000 DEA-CRS, DEA-VRS and SE scores.

TABLE 3: Input-Oriented DEA Efficiency Scores Results

Project Name	CRS technical efficiency	VRS technical efficiency	Scale efficiency	Increasing / decreasing returns to scale
AZ_I17	1	1	1	-
AZ_US60	0.886	1	0.886	drs
CA_SR22	0.387	0.488	0.793	drs
FL_95 PinedaCauseway	0.576	0.599	0.961	irs
FL_75IROX	0.575	0.764	0.753	drs
MA_RT3N	0.487	0.766	0.636	drs
MN_HW212	0.726	0.726	1	-
MN_I494Hennepin	0.483	0.533	0.906	irs
MN_ROC52	0.773	0.862	0.897	drs
NV_I15N	0.445	0.458	0.972	irs
NC_I77Surry	0.513	0.774	0.663	irs
NC_US64Knightdale	1	1	1	-
SC_CarolinaBaysPkwy	0.982	1	0.982	drs
SC_ConwayBypass	0.482	0.505	0.955	drs
TX_SH601Liberty	0.217	0.242	0.897	irs
UT_I15SaltLake	0.4	1	0.4	drs
UT_I15 NewOgdenWeber	0.658	0.66	0.998	drs
UT_I15_Utah	0.491	0.838	0.585	drs
VA_JamestownCorridor	0.692	1	0.692	irs
VA_RT288	0.613	0.717	0.855	drs
VA_RT58HilsvillePH2	0.688	0.891	0.772	irs
CA_SR125SBX	0.187	0.187	1	-
CA_SR241_FoothillEast	0.383	0.62	0.618	drs
CA_SR71SJH	0.336	0.549	0.611	drs
CA_SR91ExpressLanes	0.524	0.561	0.935	irs
CO_470TollBeltway	0.576	1	0.576	drs
FL_OsceolaPkwy	0.787	0.972	0.81	drs
NM_US70	1	1	1	-
SC_SouthernConnector	1	1	1	-
TX_183ATurnpike	0.909	1	0.909	drs
TX_SH130seg1_4	0.243	0.792	0.307	drs
TX_SH130seg5_6	0.297	0.393	0.757	drs
TX_SH45SETnpk	0.833	0.907	0.919	irs
VA_dullesgreenway	0.309	0.324	0.952	drs
VA_I495HOT	0.189	0.256	0.74	drs
VA_I895Pocahontas	0.129	0.141	0.912	irs
VA_US460	0.343	0.534	0.643	drs

Notes: Project cost (2012 US Dollar) Output: lane-mileage, number of bridges, number of interchanges

Project Name	DEA-CRS 3 Output	DEA-CRS w/o Interchange	DEA-CRS w/o bridge	DEA-VRS 2 Output
AZ_I17	1	1	1	1
AZ_US60	0.886	0.746	0.886	1
CA_SR22	0.387	0.337	0.387	0.488
FL_95 Pineda Causeway	0.576	0.551	0.576	0.599
FL_I75ROX	0.575	0.575	0.392	0.764
MA_RT3N	0.487	0.487	0.401	0.766
MN_HW212	0.726	0.698	0.371	0.726
MN_I494Hennepin	0.483	0.36	0.483	0.533
MN_ROC52	0.773	0.744	0.505	0.862
NV_I15N	0.445	0.445	0.225	0.458
NC_I77Surry	0.513	0.431	0.513	0.774
NC_US64Knightdale	1	1	0.616	1
SC_Carolina BaysPkwy	0.982	0.982	0.524	1
SC_ConwayBypass	0.482	0.482	0.292	0.505
TX_SH601Liberty	0.217	0.164	0.217	0.242
UT_I15SaltLake	0.4	0.4	0.097	1
UT_I15 New OgdenWeber	0.658	0.658	0.36	0.66
UT_I15_Utah	0.491	0.491	0.31	0.838
VA_Jamestown Corridor	0.692	0.692	0.53	1
VA_RT288	0.613	0.571	0.471	0.717
VA_RT58 HillsvillePH2	0.688	0.645	0.483	0.891
CA_SR125SBX	0.187	0.185	0.108	0.187
CA_SR241 FoothillEast	0.383	0.383	0.141	0.62
CA_SR71SJH	0.336	0.336	0.113	0.549
CA_SR91 ExpressLanes	0.524	0.524	0.524	0.561
CO_470 TollBeltway	0.576	0.576	0.349	1
FL_OsceolaPkwy	0.787	0.632	0.787	0.972
NM_US70	1	1	1	1
SC_Southern Connector	1	1	0.361	1
TX_183A Turnpike	0.909	0.316	0.909	1
TX_SH130seg1_4	0.243	0.23	0.22	0.792
TX_SH130seg5_6	0.297	0.297	0.159	0.393
TX_SH45SETnpk	0.833	0.811	0.348	0.907
VA_DullesGreenway	0.309	0.296	0.213	0.324
VA_I495HOT	0.189	0.189	0.11	0.256
VA_I895Pocahontas	0.129	0.129	0.064	0.141
VA_US460	0.343	0.343	0.162	0.534

Note: Input-oriented DEA

I-4 (0.307), UT_I15 Salt Lake County (0.400), CO_470 Toll Beltway (0.576), UT_I15 Utah County (0.585), and CA_SR71 San Joaquin Hills (0.611). Regarding increasing/decreasing returns to scale, the results were mixed: 10 DMUs demonstrated increasing returns to scale, while 21 DMUs had decreasing returns to scale. DMUs with increasing returns to scale can be interpreted as to be over-utilizing resources, while DMUs with decreasing returns to scale can be interpreted as to be underutilizing resources (31).

The authors then investigated the robustness of the DEA results by conducting a sensitivity analysis, by removing one of the output variables at a time, while keeping the input variable. Table 4 summarizes the results of the sensitivity analysis: DEA-CRS scores for each of the output mix patterns and the DEA-VRS scores of the full model are listed. If the efficiency score of a DMU is smaller when removing a variable, then it signifies that the variable is the weakness for the particular DMU. For example, the full model DEA-CRS score of AZ_US60 is 0.886, while the score decreases to 0.746 when removing the interchange variable: this variable in this case is constraining the solution set.

The number of efficient DMUs for the 3 output DEA-CRS model was four, but when removing the bridge variable, the number of efficient DMUs decreased to two DMU. NC_US64 Knightdate and SC_Southern Connector became inefficient. The number of efficient DMU did not change when removing the interchange variable.

DEA input oriented model also enables estimation of target input levels, which indicates the minimally required level of input to achieve the same level of outputs, assuming the model is correctly specified. Table 5 presents the DEA-VRS scores, the actual project total costs (in millions of 2012 US dollar), and the target input. If the DMU is efficient (i.e. the efficiency score is 1.00), then the target input would be the same as the actual cost. For example, the DEA-VRS score of AZ_I17 project was 1.00, thus both the actual cost and the target input were $116.5 million.

The problem with variable choices becomes evident when DMUs have low efficiency scores. The DEA-VRS score of VA_I895 Pocahontas Parkway project was 0.141, while the actual cost of the initial construction of the project was $826.6 million (in 2012 dollars): the target input was $116.7 million. A number of factors can explain this unrealistic gap: for example, the bridge over James River, which is one of the highlights of the project, is not accounted with proper magnitude. Similar issues can be found for most of the DMUs with low efficiency scores and large gaps between the actual and target inputs. Therefore, it is likely that the results of the DMU analyses in this study require more sophisticated variable specification and improved data quality.

TABLE 5: Target Input of DMUs, Compared to the Actual Project Cost

Project Name	DEA-VRS	Actual Cost (2012 $M)	Target input
AZ_I17	1	116.508	116.508
AZ_US60	1	234.876	234.876
CA_SR22	0.488	465.977	227.288
FL_95PinedaCauseway	0.599	208.613	125.06
FL_75IROX	0.764	501.918	383.355
MA_RT3N	0.766	504.614	386.364
MN_HW212	0.726	275.047	199.743
MN_I494Hennepin	0.533	162.494	86.625
MN_ROC52	0.862	259.734	223.762
NV_I15N	0.458	274.368	125.741
NC_I77Surry	0.774	64.2369	49.692
NC_US64Knightdale	1	165.605	165.605
SC_CarolinaBaysPkwy	1	306.172	306.172
SC_ConwayBypass	0.505	534.48	269.866
TX_SH601Liberty	0.242	402.841	97.418
UT_I15SaltLake	1	2292.16	2292.16
UT_I15NewOgdenWeber	0.66	266.451	175.761
UT_I15_Utah	0.838	1157.44	970.205
VA_JamestownCorridor	1	40.1467	40.147
VA_RT288	0.717	309.322	221.882
VA_RT58HilsvillePH2	0.891	90.3671	80.511
CA_SR125SBX	0.187	948.185	176.984
CA_SR241_FoothillEast	0.62	1189.22	737.436
CA_SR71SJH	0.549	1309.13	718.826
CA_SR91ExpressLanes	0.561	203.052	113.901
CO_470TollBeltway	1	1612.14	1612.14
FL_OsceolaPkwy	0.972	222.146	215.838
NM_US70	1	161.842	161.842
SC_SouthernConnector	1	290.779	290.779
TX_183ATurnpike	1	352.476	352.476
TX_SH130seg1_4	0.792	1717.53	1360.207
TX_SH130seg5_6	0.393	1392.15	547.331
TX_SH45SETnpk	0.907	167.274	151.665
VA_dullesgreenway	0.324	546.678	177.357
VA_I495HOT	0.256	2100.22	537.167
VA_I895Pocahontas	0.141	826.644	116.673
VA_US460	0.534	1700	907.532
Note: Input-oriented DEA			

DISCUSSION AND CONCLUDING REMARKS

P3s are increasingly used in the U.S. to deliver vitally needed infrastructure. While economic theories have suggested that the procurement mechanism may provide cost efficiency, policy debates in the U.S. typically focus on the access to private capital as its main benefit. Importantly, presumed cost savings of the P3s have not been empirically supported, because of data limitation due to their long concession duration and proprietary nature of project data that are necessary for conducting such analysis. The contribution of this study is to be an early empirical analysis on the relative costs of U.S. P3s. Also, this is one of the first studies that employ DEA to analyze the efficiency of infrastructure project.

The findings demonstrated, however, the challenges for the future than insights that could immediately inform decision makers. In this study, global efficiency score (DEA-CRS), local efficiency scores (DEA-VRS), Scale Efficiency and increasing/decreasing Returns to Scale were obtained for each DMU (capacity expansion tolled and non-tolled motorway projects in the U.S. with P3 arrangements). The DEA efficiency scores showed unusual variations: some DMUs, for example, had unusually low efficiency scores. It is likely that the quality of data needs to be improved for more meaningful results, by better capturing: project outputs (e.g. safety features, signage, and toll collection systems), and; activities involved in the delivery of projects (e.g. earthwork, right-of-way acquisition).

There are a number of environmental factors that are likely to affect efficiency levels of DMUs. For example, locating in a rural region or in an urban area may result in profound difference of cost efficiency, due to costlier land acquisition and labor costs. Areas, per capita income, and other characteristics of each project (or perhaps the state where the project is located) may all have considerable effect on the cost structure. The simple DEA framework used in this study is incapable of differentiating the effect of each environmental variable. Daraio and Simar have proposed a DEA technique that allow including environmental variables in DEA analyses (41). One of the steps to extend the analysis in this study is to introduce environmental variables into the frontier models, so that the magnitude of each variable's influence can be estimated, in order to deepen the understanding of the relationship between specific institutional and market conditions and project performance.

Finally, the focus of this study was the efficiency of infrastructure delivery, which is independent from the efficient use of resources at the societal level. Parajuli and Haynes, for example, in discussing an analysis of broadband availability (42), suggested that the availability is different from broadband access (31). Likewise, even if a motorway project has been delivered in a cost efficient manner, the society would still be misallocating the resources, should the project suffer from low usage. Evidently, the analytical framework used in this study would need to be considerably extended to address such efficiency concerns at the societal level. Accounting for the usage of the DMUs may drastically alter the production function for which the DEA estimates the efficiency. Future extensions of this study will attempt to address these remaining questions.

P3s were originally proposed to improve efficiency in project delivery, but it has not been clear whether the presumption of cost savings truly holds in actual projects.

Provided potential improvements suggested in this study can be addressed, the analytical framework employed in this study may present considerable prospect for drawing valuable insights to aid decision making regarding alternative procurement mechanisms for infrastructure delivery.

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REFERENCES

1. J. Weingart B., R. Pieplow, R. Driskell, S. Gaj, M. J. Garvin, D. Holcombe, M. Saunders, J. Seiders, Jr., and A. Smith (2009), Public-Private Partnerships for highway infrastructure: capitalizing on international experience, Federal Highway Administration, Technical Report FHWA-PL-09-010, Washington, D.C.
2. T. Valila (2005), How expensive are cost savings? On the economics of public-private partnerships, EIB Paper 4/2005, European Investment Bank.
3. U.S. Government Accountability Office (2008), "Highway Public-Private Partnerships: more rigorous up-front analysis could better secure potential benefits and protect the public interest," Report to Congressional Requesters GAO-08-44, Washington, D.C.
4. Federal Highway Administration (2011), Financial analysis of transportation-related Public Private Partnerships, Office of Inspector General CR-2011-147, Federal Highway Administration, Washington, D.C.
5. M. Dewatripont and P. Legros (2005), Public-private partnerships: contract design and risk transfer, EIB Paper 5/2005, European Investment Bank.
6. M. J. Garvin and Y. J. Cheah (2004), Valuation Techniques for Infrastructure investment Decisions, Construction Management and Economics, vol. 22, no. 5, pp.373-383.
7. J. F. Traub (1985), Complexity of Approximately Solved Problems, Journal of Complexity, vol. 1, no. 1, pp. 3-10.
8. F. Blanc-Brude, H. Goldsmith, and T. Valila (2006), Ex ante construction costs in the European road sector: a comparison of public-private partnerships and traditional public procurement, EIB Paper 1/2006, European Investment Bank.
9. J. R. Ahlin (2012), Introduction to public-private partnerships (P3s), U.S. Department of Transportation Office of Innovative Project Delivery.
10. U.S. Congressional Budget Office (2012), Using public-private partnerships to carry out highway projects, Washington, D.C.
11. N. Daito, C. Zhenhua, and J. Gifford (2013), Research needs for Virginia transportation public private partnership policy, presented at the 92nd Transportation Research Board Annual Meeting, Washington D.C.
12. OECD International Transport Forum (2008), Transport Infrastructure Investment: options for efficiency, OECD/ITF, Paris.
13. G. Hampton, A. N. Baldwin, and G. Holt (2012), Project delays and cost: stakeholder perceptions of traditional v. PPP procurement, Journal of Financial Management of Property and Construction, vol. 17, no. 1, pp. 73–91.
14. G. A. Hodge, C. Greve, and A. E. Boardman, Eds. (2010), International handbook on public private partnerships, Edward Elgar Publishing, Inc., Cheltenham ; Northampton, MA.
15. E. Maskin and J. Tirole (2008), Public–private partnerships and government spending limits, International Journal of Industrial Organizations, vol. 26, no. 2, pp. 412–420.

16. P. DeCorla-Souza, D. Lee, D. Timothy, and J. Mayer (2013), Comparing public-private partnerships with traditional procurement: incorporating considerations from benefit-cost analysis, presented at the Transportation Research Board 92nd Annual Meeting, Washington, D.C.

17. D. Morrallos, A. Amekudzi, Ross Catherine, and M. Meyer (2009), Value for money analysis in U.S. transportation public-private partnerships, Transportation Research Record, Journal of Transportation Research Board, vol. 2115, no. 1, pp. 27–36.

18. HM Treasury (2006), Value for money assessment guidance." HM Treasury.

19. J. Burr, R. Mackay, and M. Mills (2011), P3 business case development guide, PPP Canada.

20. Federal Highway Administration (2012), Establishing a public-private partnership program: a primer, U.S. Department of Transportation.

21. G. Dudkin and T. Välilä (2006), Transaction costs in public-private partnerships: a first look at the evidence, Competition and Regulation in Network Industries, vol. 7, no. 2, pp. 307–331.

22. D. Chasey, W. Maddex, and A. Basal (2012), A comparison of public-private partnerships and traditional procurement methods in North American highway construction, presented at the Transportation Research Board 91st Annual Meeting.

23. P. Rouse, M. Putterill, and D. Ryan (1997), Towards a general managerial framework for performance measurement: a comprehensive highway maintenance application," Journal of Productivity Analysis, vol. 8, no. 2, pp. 127–149.

24. C. Worthington (2000), Cost efficiency in Australian local government: a comparative analysis of mathematical programming and econometrical approaches," Financial Accounting Management, vol. 16, no. 3, pp. 201–223.

25. Geys and W. Moesen (2009), Measuring local government technical (in) efficiency, Public Perform and Management Review, vol. 32, no. 4, pp. 499–513.

26. X. Xue, Q. Shen, Y. Wang, and J. Lu (2008), Measuring the productivity of the construction industry in China by using DEA-based Malmquist Productivity Indices, Journal of Construction Engineering and Management, vol. 134, no. 1, pp. 64–71.

27. C. Lin and H. Huang (2010), Improved baseline productivity analysis technique, Journal of Construction Engineering and Management, vol. 136, no. 3, pp. 367–376.

28. Horta, A. Camanho, and J. Da Costa (2010), Performance assessment of construction companies integrating Key Performance Indicators and Data Envelopment Analysis, Journal of Construction Engineering and Management, vol. 136, no. 5, pp. 581–594.

29. J. Cowie and D. Asenova (1999), Organisation form, scale effects and efficiency in the British bus industry, Transportation, vol. 26, no. 3, pp. 231–248.

30. X. Chu, G. J. Fielding, and B. W. Lamar (1992), Measuring transit performance using data envelopment analysis, Transportation Research Part A: Policy and Practice, vol. 26, no. 3, pp. 223–230.

31. J. Parajuli and K. E. Haynes (2012), Patterns of broadband efficiency in the U.S," Growth Change, vol. 43, no. 4, pp. 590–614.

32. E. Pels and P. Rietveld (2008), Cost Functions in Transport, in Handbook of Transport Modelling, 2nd ed., Oxford, UK: Elsevier, pp. 381–394.

33. Kalb, B. Geys, and F. Heinemann (2012), Value for money? German local government efficiency in a comparative perspective, Applied Economics, vol. 44, no. 2, pp. 201–218.

34. Charnes, W. W. Cooper, and E. Rhodes (1978), Measuring the efficiency of decision making units, European Journal of Operational Research, vol. 2, no. 6, pp. 429–444.

35. R. D. Banker, A. Charnes, and W. W. Cooper (1984), Some models for estimating technical and scale inefficiencies in Data Envelopment Analysis," Management Science. vol. 30, no. 9, pp. 1078–1092.

36. L. M. Seiford and R. M. Thrall (1990), "Recent developments in DEA: The mathematical programming approach to frontier analysis," Journal of Econometrics, vol. 46, no. 1–2, pp. 7–38.

37. M. T. Balaguer-Coll, D. Prior, and E. Tortosa-Ausina (2010), Decentralization and efficiency of local government, Annals of Regional Science, vol. 45, no. 3, pp. 571–601.

38. L. M. Seiford, K. Tone, and W. W. Cooper (2007), Data Envelopment Analysis: a comprehensive text with models, applications, references and Dea-solver software, 2nd ed. Dordrecht: Springer.

39. Charnes, W. W. Cooper, and E. Rhodes (1981), Evaluating program and managerial efficiency: an application of Data Envelopment Analysis to program follow through, Management Science, vol. 27, no. 6, pp. 668–697.

40. T. Coelli (1996), A Guide to DEAP Version 2.1: A Data Envelopment Analysis (computer) program, Australia.

41. Daraio and L. Simar (2005), Introducing environmental variables in nonparametric frontier models: a probabilistic approach," Journal of Productivity Analysis, vol. 24, no. 1, pp. 93–121.

42. T. H. Grubesic (2010), Efficiency in broadband service provision: a spatial analysis, Telecommunications Policy, vol. 34, no. 3, pp. 117–131.

PUBLIC-PRIVATE PARTNERSHIP IN TRANSPORTATION: FOCUS ON THE TRAVELER INFORMATION PROJECTS

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ABSTRACT

Public Private Partnership (PPP) has been viewed as an effective method –even during financial hardship- to get hefty transportation projects off the ground. In this manuscript we report on the application of the PPP in Traveler Information Provision (TIP). The TIPs assist commuters in making better travel decisions, thereby leading to increased mobility and more efficient travel. Such initiatives have been greatly discussed in the developed countries while it is in early stages in the developing countries. In this study, we assess the PPP's opportunities in TIP in the case of a developing country; Tehran, Iran. To this end, we first study the factors contributing to the TIP's effectiveness by analyzing commuters' behavioral changes in response to currently broadcasted Radio Traffic Information (RTI). The analysis highlights factors such as commuter characteristics, trip purpose, and the content of RTI information highly significant, which in turn usher to some potential markets and strategies for investment in TIP.

INTRODUCTION

In light of tight or shrinking public funding, a business model known as the public–private partnership (PPP) emerged in Europe in the 1980's (1-4). The PPP is a long-term agreement between public and private sectors with risks and benefits shared between parties (2, 5-7). Given the recent ongoing economic crisis, the PPP seems poised to become even more widespread (4). Also the private sector has been equipped with new types of liquidities to take a bigger role in the PPP (3).

The PPP is still an evolving business model across developed countries and it is in its infancy stages in the developing countries (3). The literature has shown little attention to the case of developing countries. In this study we will investigate PPP opportunities for TIP in the case of the city of Tehran, Iran. Our methodology has two parts: (i) what factors contribute to the success of traveler information in the city of Tehran? To answer this question we use an attitudinal survey conducted in 2002 in which the commuters' behavior to Radio Traffic Information (RTI) are investigated. Bagloee et al (12) showed that the survey is still relevant for current traffic behaviors in the city of Tehran. RTI is a representative of a broader range of TIP such as variable message signs and traveler information messaging subscriptions (12, 17-21). The simplicity of radio transmission technology has made the usage of RTI widespread even in the developing countries (12,22,23). Hence the methodology developed in this study can be applied to other developing countries. The effectiveness of TIP shall be measured by investigating the extent to which it causes commuters to diverge from their normal travel plan (12,24-26). (ii) We conduct a review of literature and previous practices to identify pros and cons of the PPP in both developing and developed countries. In the end, we shall outline a business scenario for PPP in the potential markets identified in the first phase.

A special issue published by the journal of Transport Review has compiled latest developments on the PPP in the transportation with focus on the European Countries (1, 27-30).

PHASE 1: MODELING THE EFFECTIVENESS OF TRAVELER INFORMATION PROVISIONS (TIP) IN TEHRAN

The RTI in Tehran, Iran known as Radio-Payam Station broadcasts traffic reports including descriptions of overall traffic conditions on the main corridors, accident reports, traffic jam location and their clearance, and recommended substitute routes. Sharif University of Technology, Tehran conducted a survey to study the impacts of Radio-Payam in Tehran. The results of the survey and the ensuing analysis have been published in two research articles (12,33) in which a variety of models including ordered logit/probit, multinomial logit, nested logit, neuro-fuzzy, neural networks have been developed. In this section, without going through the mathematical details of the model the results are highlighted and discussed. As mentioned before, the commuters' propensities of diversion subject to en-route traveler information (the RTI) are modeled.

Table 1 presents a summary of interpretations of the modeling results. The table identifies the factors contributing to drivers' rate of diversion, which also measure the potential for TIP markets. For instance the impact of variables A3560 (age between 35 and 60) and HCEGA (commuters with higher education) indicates that the PPP investments ought to target this market segment.

TABLE 1: Result Of The Modeling And Comparisons To The Findings In The Literature

Who has higher propensity to en-route diversion? (Relevant variables are shown with bold font)	References agreed with	References disagreed with
CHDTC and **CHURC:** Those who change their departure time or divert to other routes due to congestion	26, 33, 34, 35, 36, 37, 38	
PRLRA and **OLSRD*:** Those who normally listen to RTI or who found RTI effective. They are exposed to traffic news and travel advice including broadcast recommendations to divert to alternative routes.	8, 11, 24, 26, 32, 33, 34, 36, 37, 38, 39, 40, 41, 42	
FAMRT: Familiarity, those who know more alternative routes. More spatial knowledge of the road network may provide more opportunities for and familiarity with route diversion.	8, 24, 33, 39, 41, 43, 44, 45	37, 46
JOEMS and **LARWP:** Those whose occupations are office or military employees and who are required to arrive at work on time by any means including diversion.	10, 11, 17, 23, 26, 34	33
LNDTM: Those who experience higher travel times. They are eager to lower their travel time by any means, including diversion.	9, 10,11, 34, 39, 43	9
A3560: Adult and elderly people are less likely to divert. This can be due to a risk aversion issue. Elderly people are risk averse.	9, 10, 45, 46, 47	48, 49
PAT520: Those who prefer to arrive between 5 and 20 minutes early to work. Like elderly people, they are risk averse so they are less likely to divert.	17, 22, 46, 47	
HCEGA: People with higher education levels; college graduates or postgraduate work. Their value of time is high and they are likely to divert to avoid congestion.	44, 46, 49	50
Gender: Some studies have shown that male commuters are more inclined to change their trip plan including diversion. This study did not find such indications.	23, 48, 49, 50	17, 44, 45, 46
*The coefficient of **OLSRD**, while falling within a statistically meaningful interval (with respect to t-statistics), counter-intuitively is negative in the ordered models and U3 ("very often" diversion) of NL. It is positive in the MNL and U1 ("rarely" diversion) of NL. This implies that the self-stated effectiveness of RTI on diversion does not have a positive impact on en-route diversion. One reason might be that the number of respondents who stated that the effectiveness of RTI on their diversion was "high" is very marginal (7 out of 374 records). Therefore, we can say that for those who did not find RTI effective, less en-route diversion took place.		

Furthermore, to see how the findings of this study compare to the literature, we carried out a thorough literature review, which is also shown in Table 1. As can be seen, there is consensus in the literature about most of the factors except the gender. It seems that gender is not a universal factor for the TIP services market. Rather, it varies depending on context. In the context of our case-study (Tehran), we did not find gender to affect the market for RTI.

PHASE 2: PROPOSED STRUCTURE OF PUBLIC-PRIVATE PARTNERSHIP (PPP) IN TIP

In this section, based on the information presented in Table 1, we first describe the markets in which TIP has been shown to be effective. We then set up a framework for PPP investment in the markets where TIP is found to be effective. The local constraints in this case study (Tehran), and the challenges experienced in similar applications of PPP across the globe are considered.

Potential Markets for PPP in TIP

According to the variables highlighted in Table 1, a number of potential markets can be identified which should be targeted for investment. These are presented in Table 2.

TABLE 2: Potential Markets or Strategies for Traveler Information Provision (TIP)

Factors found effective in drivers' diversion	Initiatives or Potential Target Markets
CHDTC (those who change their departure time) Those who can change their departure time may constitute a share of travel demand in which the trip is more flexible than the work trip, such as social, recreational, shopping and other trip purposes. It may also indicate the non-morning rush hour trips with no need for travelers to reach their destinations at a certain time.	Nonwork trips, social trips, shopping trips, non morning peak trips, PM peak hour trips.
CHURC (those who divert to other routes) There must be alternative routes to divert to. This environment may exist in urban areas, interconnected highway networks, and CBD areas with multiple access roads, etc.	Urban roads, denser highway networks, CBD areas
PRLRA (those who tune to RTI) This indicates that the TIP sources must be interesting/entertaining enough to attract an audience in the first place. For TIP media like radio, broadcasting entertainment programs, popular music and initiating promotions are of such initiatives.	Making the sources of TIP attractive, entertaining and etc.
OLSRD (those who found RTI effective). This indicates that the TIP sources must provide quantitative, prescriptive, customized, detailed, easy to understand, interactive traffic information.	Supplying prescriptive and quantitative traffic information
FAMRT (those who know alternative routes). This has two aspects. First, the TIP must improve commuters' spatial knowledge of the traffic via interactive maps, GPS devices etc. Second, the TIP may target travel demand where the travelers are already familiar with the network due to frequency of use. Work trips are an example of this.	In-vehicle GPS device, interactive traffic maps, work related trips
JOEMS, LARWP and **PAT520** (office/military occupations and risk averse people who prefer to arrive 5 to 20 minutes early to their destination) These will mainly be morning rush hour, scheduled, appointments or emergency trips. TIP services can serve these markets directly. For example providing processed and customized information to employees of large companies, delivery companies, police, civil defense, ambulances, or taxi companies via GPS or wireless technologies.	Morning peak hour trips, work trips routing services to delivery fleets, taxis, police, ambulances via GPS, wireless technologies
LNDTM (higher travel time) This refers to longer distance trips, which could be travel from suburbs to the city center. The TIP ought to focus on this demand especially during the rush hour.	Trips between suburb to city center
A3560 (age between 35 and 60) Elderly people are unlikely to divert. Young commuters are more likely to be potential TIP service customers.	Young population
HCEGA (higher education; grads or above). Because their value of time is higher, they are likely to divert to avoid congestion. They may be more technologically savvy too.	Educated people, high income people, technology savvy people

A Framework Implementing TIP through a PPP tailored to the City of Tehran, Iran

In summary governments around the world are shifting from traditional public funding sources for some activities and relying on the private sector (7). Even the developing countries are seeing a surge of private investment. Hence PPP may be inevitable. The content of TIP, the commodity in this market, must be integrated, detailed, quantitative, customized, prescriptive, and easy-to-understand to appeal to commuters. The market is highly sensitive to the price of TIP. To set up a self-sustaining business model, the target market has to be segmented into commuters and corporate consumers such as taxi companies, deliveries services, freight transport, etc. Multiple markets help to diversify the sources of revenues for the PPP, which is essential to ensure profits for the private sector party.

It is important to understand that the TIP process occurs in three stages (i) data collection, (ii) data fusion and (iii) data distribution. At first, the entire process was established, owned and operated by the public sector with a focus on collecting data primarily for operational decision support and secondarily for providing information to the public. Later on, the private sector became involved in the second and third stages. The private sector did not participate in data collection because the cost of data collection was not affordable, or data was already being collected by the public agencies. Gradually, technological progress made data collection cheaper. In the meantime, the private sector accumulated funds were always looking for investment opportunities. They began to understand the value of roadway data and the profit to be made from TIP. These factors attracted the private sector to become involved in data collection too. Interestingly the public sector also shifted from early trends of data collection for operational decisions to become more involved in stage (ii) data fusion and stage (iii) distribution. In addition to traffic data, some governments control a variety of other data collection efforts such as weather, parking availability, and public transportation schedule and location information. Thus integrating all these data would be in the best interest of the traveling public.

The degree to which the private and public partners in the partnership share responsibilities, risks and rewards varies and controls the different types of PPP: There is a spectrum of partnership types. On one end there is zero private involvement (all public) while at the other end there is no public involvement (all private). In between, the degree to which the private partner is involved results in a variety of agreements (64) such as O&M: Operations and Maintenance, BOT: Build-Operate-Transfer, DBM: Design-Build-Maintain and etc. The business models that have shown successful performance for both parties are located somewhere near the “all private” end of the spectrum, where the private sector controls all the aspects of the TIP and the public sector supervises the activities.

Private investment in TIP is risky, as is any commercial venture. In addition to technology, success of the venture requires a politically, institutionally and commercially stable context as well as advanced and transparent legislation. The developing countries, including our case study, lack this environment in one way or another. For the case of Tehran, Iran there are additional impediments. Due to recent political unrest in the Middle East, the public agencies often view the traffic data as a security matter. Therefore, the smooth flow of traffic data collected by these devices is hindered in some aspects. For example, all traffic cameras across the city are owned and operated by the government (65). Hence there is less opportunity for private partnership in data collection. For providing TIP information based on publicly owned roadside equipment, stage (ii) and stage (iii) are areas most open to private sector investment. Consequently PPP in Tehran, Iran would start its journey the way TIP/PPP arrangements were initiated in the developed countries: the public sector first invested in the traffic data collection. Raw data collected by public agencies may be sold or transferred to the private sector. The private sector would process the raw data to generate value-added products such as data suitable for performance monitoring for the public sector, interactive maps, traffic advisories, routing guidance services and etc. The private sector would be allowed to seek revenue via various means such as selling the final products to the end-users, selling advertisements on websites and telephone applications, etc.

In the remaining of discussion we outline private partnership opportunities in the data fusion and distribution, stages (ii) and (iii).

In Table 2, potential markets or initiatives to focus on for promoting successful PPP arrangements in TIP in the city of Tehran are highlighted. The available TIP technologies required to transmit the information to the end-users in Tehran are not far behind the rest of the world. Technologies such as internet connectivity, wireless communication, television, radio, variable message signs (VMS), and GPS based navigation devices are available. Hence the tools to implement the modern TIP consistent with global standards are available. For this program to move forward using PPP, the market demand must be studied carefully. As discussed before the market for real-time travel information is split into two basic markets: commuters and corporate consumers.

Commuters

Commuters’ general resistance to paying for traffic information is high, but young, educated, or wealthy populations have shown a willingness to pay for traffic information. Trips destined to the CBD area, morning and evening peak hour trips, work trips, non-essential trips, and suburban trips must be targeted. The contents and format of the product's information is crucial to revenue generation. It must be accurate, quantitative and prescriptive and should include some combination of the following: time delay caused by congestion, optimum transit trip plans, transit vehicle station arrival times, expected destination arrival times, available parking spaces, specific alternative routes, weather forecasting, and etc. Such information is currently available in various forms. For example real-time average roadway speed is displayed online on an interactive map via Tehran municipality website (66). Highways and main arterials in the city of Tehran are equipped with VMS displaying messages regarding incidents, advice for specific alternative routes, traffic bottlenecks ahead, etc., are already in use. Radio Traffic Information (RTI) services has been operational since 1993 (67). The transit system information is currently being integrated using advanced navigation and communication technologies such as GPS, RFID and Wimax. In the near future, commuters will be able to receive a variety of information such transit vehicle arrival times at stations, transit trip plans, and on-board information (68,69).

The widespread usage of cell/smart phones and growing internet penetration as well as in-vehicle navigation system (GPS) in the city of Tehran provides a favorable platform to promote TIP. According to historical experience leading to revenue generation, the value-added data should be supplied in two packages: free-of-charge information and premium paid information. Non-customized information such as current available services should be free-of-charge. However the private sector may generate revenue by selling advertising space on the product (web pages, cell phone applications, VMS signs) instead of charging the information consumer. In the second package the customized information is sold to the consumer via various media such as cell phone alerts, email alerts, travel information call center, pay per use internet access and GPS navigation. Subscription models have not shown satisfactory results. Commuters prefer to pay for the amount of service they use.

With regard to GPS, there is a premature business model, which is currently operational in Tehran: As knowledge and technology improves, the price of GPS technology is declining. Thus, some telecom companies are including GPS applications on cell/smart phone and some new cars are equipped with standard GPS devices. Currently, GPS devices assist the user by generating positioning as an input to routing based on the statistic data (70).

Corporate

Inefficient fleet routing/scheduling practices put a corporation out of business (71), whereas improved efficiency can increase profitability by eliminating wasted time and fuel and guaranteeing on-time performance. Therefore, all organizations, which operate vehicle fleets, such as delivery companies, taxi operators, police departments, public works departments, and the civil defense fleets, are potential sources of substantial revenue for TIP. Some of these Tehran entities, for instance taxis and buses, are being equipped with GPS locating devices (70). The GPS market is growing such that the market can be tapped. A similar business model described previously for commuters can be applied to the corporate customer. Since the motives of these organizations differ from the individual commuter, i.e. to improve profitability, reduce cost, and attend to emergencies in a timely fashion, these entities seem more likely to be willing to pay for the ability to achieve these goals. The private sector ought to be better equipped to deal with such homogenous individual corporate needs rather than individual commuters.

A proposal for Organization Chart

The paper tries to identify ways to expand private sector participation in TIP. Tehran Traffic Control Company (TTCC) is currently in charge of collecting and compiling a variety of traffic data in Tehran, as well as running Radio-Payam. Hence, the TTCC would be the natural public partner for the business model proposed in this study. The TTCC has developed applications for smart phones and established a website to provide traffic information. For instance drivers can receive real time traffic data or map on smart phone via various communication technologies such as radio data system (RDS), short message service (SMS), multimedia messaging service (MMS) and general packet radio service (GPRS) (65,72,73). The information is disseminated largely free of charge, hence the operations are financed by the public sector (here Tehran Municipality).

Given the ongoing operations, knowledge and technology with TTCC, the TTCC can become the leader in promoting a private partnership in TIP. The TTCC is currently operating as one affiliated division of the Tehran Department of Transportation in Tehran Municipality. Accordingly it is recommended that TTCC should be converted to an independent bureau in the municipality with statutory authority to outreach to private sector and to promote mutual partnership.

SUMMARY AND CONCLUSION

It is evident that informed commuters make better travel decisions, which results in more efficient travel for the individual and improved road network performance. We explored the opportunity for Public-Private Partnership (PPP) investment in Travel Information Provision (TIP) for the case of a developing country (Tehran, Iran). The developing countries are very large transportation markets. In fact, they are the source of more than half of the global transportation demand, thus it is worthwhile to improve mobility efficiency in these countries. The TIP is a relatively affordable traffic management tool, which may improve the performance of existing transportation system investments, or delay the need to implement costly new construction projects. Fiscal problems in the developing countries coupled with available resources searching for investment opportunities in the private sector may make the PPP in the TIP a win-win partnership.

In the first phase we investigated commuters' behavioral changes in response to the presence of traffic information. We used a behavioral survey conducted to investigate the impact of traffic information broadcasted by a radio station in the city of Tehran. The effectiveness of TIP (in the form of Radio Traffic information (RTI)) was interpreted as the degree to which the commuters divert from their routine routes. Two models (Multi-Nominal Logit and Nested Logit) were developed. Using the models, we tried to identify some latent traveler characteristics, which resulted in increased impacts of the existing free traffic radio information (RTI). The results were a set of factors such as trip purpose, driving time, and drivers' characteristics that were found to be significant contributors to the diversion. Such factors indicate the potential markets for TIP and possible private partnership. Since the RTI is free the results of analysis (potential markets) will not be biased to some specific segments of customers.

In the second phase, we reviewed past PPP implementation experiences. As a result of the review, we listed opportunities, challenges and findings related to PPP. We found that PPP in the TIP is a risky investment unless some prerequisites were in place. The prerequisite context includes foundational technology (existing communications infrastructure, widespread internet and wireless communication), information content provided, transparent and advanced legislation, as well as politically and institutional stability. We found some drawbacks in the undertaken case study of Tehran, especially that the authority perceives that traffic data collection is security sensitive which hinders the free flow of information. With respect to these environmental conditions, we outlined some business scenarios for private partnership investment in the potential markets. The key findings for the case study are as follows (i) data collection would remain under the control of the government. The private sector either purchases the raw data or receives it based on a special agreement with the government. The private partner processes and delivers the product to the customer. (ii) With respect to "purchasing power" the market should be stratified between individual travelers (commuters) and corporate users. (iii) The final products, or value-added information, must be divided into free-of-charge and premium paid information. Customers desire customized and interactive products. The more the products are customized and useful for the individual, the more likely those products are good candidates for inclusion in the paid category. (iv) With respect to available technologies in Tehran, a variety of traffic information is being collected but not yet processed and distributed, which makes it an untapped market. (v) Integration of the available real-time speed data and the growing GPS technologies in cell/smart phone and in-vehicle GPS devices indicates a potentially profitable business in which fleet operators are the main customers.

REFERENCES

1. Roumboutsos, A. Public Private Partnerships in Transport Infrastructure: An International Review. Transport Reviews, Vol. 35, No. 2, 2015, pp. 111-117.
2. Sharma, D.K., Cui, Q., Chen, L. and J.K. Lindly. Balancing Private and Public Interests in Public–Private Partnership Contracts Through Optimization of Equity Capital Structure. In Transportation Research Record: Journal of the Transportation Research Board, No. 2151, Transportation Research Board of the National Academies, Washington, D.C., 2010, pp. 60–66.
3. Estache, A., Juan, E., and L., Trujillo. Public-Private Partnerships in Transport. The World Bank Sustainable Development Vice-Presidency, December 2007. http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2007/12/12/000158349_20071212085739/Rendered/PDF/wps4436.pdf. Accessed by July 2012.
4. Resor, R.R. Public-Private Partnerships: When Are They Appropriate for Transportation Infrastructure? CD-ROM. Transportation Research Board of the National Academies, Washington, D.C., 2012, (12-1738).
5. Grimsey, D., and M.K., Lewis. Evaluating the risks of public private partnerships for infrastructure projects. In International Journal of Project Management, Vol. 20, No. 2, 2002, pp.107-118.
6. Sanghi, A., A. Sundakov, and D. Hankinson. Designing and Using Public–Private Partnership Units in Infrastructure: Lessons from Case Studies Around the World. Gridlines, PPIAF, World Bank Group. No. 27, 2007, pp. 1–5.
7. Morallos, D., Amekudzi, A., Ross, C. and M., Meyer. Value for Money Analysis in U.S. Transportation Public-Private Partnership. In Transportation Research Record: Journal of the Transportation Research Board, No. 2115, Transportation Research Board of the National Academies, Washington, D.C., 2009, pp. 27–36.
8. Wardman M., Bonsall P.W., and J.D. Shires. Driver Response to Variable Message Signs: A Stated Preference Investigation. Transportation Research Part C, Vol. 5, No. 6, 1997, pp. 389–405.
9. Abdel-Aty, M.A., Kitamura, R., and P.P., Jovanis. Using Stated Preference Data for Studying the Effect of Advanced Traffic Information on Drivers' Route Choice. Transportation Research Part C, Vol 5, No. 1, 1997, pp.39-50.
10. Wolinetz, L., Khattak, A. and Y.B. Yim. Why will some individuals pay for travel information when it can be free? Analysis of a Bay Area travel survey. In Transportation Research Record: Journal of the Transportation Research Board, No. 1759, Transportation Research Board of the National Academies, Washington, D.C., 2001, pp. 9–18.
11. Khattak, A., Y. Yim, and L. Stalker. Willingness to Pay for Travel Information. Transportation Research Part C: Emerging Technologies, Vol. 11, No. 2, 2003, pp. 137–159
12. Bagloee, S. A., A. Ceder, and C. Bozic. Effectiveness of en route traffic information in developing countries using conventional discrete choice and neural-network models. Journal of Advanced Transportation, Vol. 48, No. 6, 2014, pp. 486-506.
13. Gardner, L.M., Boyles, S.D. And S.T. Waller. Quantifying the benefit of responsive pricing and travel information in the stochastic congestion pricing problem". Transportation Research Part A, 2011. Vol. 45, No. 3, 2011, pp.204-218.
14. Verhoef, E. T., Emmerink, R. H. M., Nijkamp, P., and P. Rietveld. Information provision, flat and fine congestion tolling and the efficiency of road usage. Regional Science and Urban Economics, Vol. 26, 1996, pp. 505–529.
15. Emmerink, .R. H. M., E. T. Verhoef, P. Nijkamp and P. Rietveld. Endogenising demand for information in road transport. Annals of Regional Science, Vol. 30, 1996, pp. 201-222.
16. Yang, H. System optimum, stochastic user equilibrium, and optimal link tolls. Transportation Science, Vol 33, 1999, pp. 354–360.
17. Emmerink, R.H.M., Nijkamp, P., Rietveld, P., and J.N.V. Ommeren. Variable message signs and radio traffic information: an integrated empirical analysis of drivers' route choice behavior. Transportation Research Part A, Vol. 30, No. 2, 1996, pp. 135–153.
18. Zhou, Y., and J., Wu. The research on drivers' route choice behavior in the presence of dynamic traffic information, Proceedings of the 2006 IEEE Intelligent Transportation Systems Conference Toronto, Canada, 2006, pp.17–20.
19. Bierlaire, M., Thémans, M., and K. Axhausen. Analysis of driver's response to real-time information in Switzerland. European Transport, Vol. 34, 2006, pp.21-41.

20. Chiu, Y.C., and N., Huynh. Location configuration design for dynamic message signs under stochastic incident scenarios. Transportation Research Part C, Vol. 15, No. 1, 2006. Pp. 33-50.

21. Kattan, L., Habib, K.M.N., Tazul, I., and N., Shahid. Information provision and driver compliance to advanced traveller information system application: case study on the interaction between variable message sign and other sources of traffic updates in Calgary, Canada. Canadian Journal of Civil Engineering, Vol. 38, No.12, 2011, pp. 1335-1346.

22. Mamdoohi, A.R. and M. Kermanshah. Traffic Information Use Modeling In The Context Of A Developing Country. Periodica Polytechnica Ser. Transportation. Engineering. Vol. 33, No., 1–2, 2005, pp. 125–137.

23. Khoo, H. L. and G.P., Ong. Analysis of the Awareness and Utilization of Traffic Information System in Malaysia: A Discrete Choice Modeling Approach. In Transportation Research Record: Journal of the Transportation Research Record, No. 2239, Transportation Research Board of the National Academies, Washington, D.C., 2011, pp. 101–111.

24. Khattak, A. J., and A. J. Khattak. Comparative Analysis of Spatial Knowledge and En Route Diversion Behavior in Chicago and San Francisco: Implications for Advanced Traveler Information Systems. In Transportation Research Record: Journal of the Transportation Research Board, No.1621, Transportation Research Board of the National Academies, Washington, D.C., 1998, pp. 27–35.

25. Dia, H., and S., Panwai. Modelling drivers' compliance and route choice behaviour in response to travel information. Special issue on Modelling and Control of Intelligent Transportation Systems. Journal of Nonlinear Dynamics, Vol. 49, No. 4, 2007, pp. 493–509.

26. Khattak, A., X. Pan, B. Williams, N. Rouphail, and Y. Fan. Traveler information delivery mechanisms: Impact on consumer behavior. In Transportation Research Record: Journal of the Transportation Research Record, No. 2069, Transportation Research Board of the National Academies, Washington, D.C., 2008, pp. 77–84.

27. Verhoest, O. H. Petersen, W. Scherrer, and R. M. Soecipto. How Do Governments Support the Development of Public Private Partnerships? Measuring and Comparing PPP Governmental Support in 20 European Countries. Transport Reviews, Vol. 35, No. 2, 2015, pp. 118-139.

28. Liyanage, C., and F. Villalba-Romero. Measuring Success of PPP Transport Projects: A Cross-Case Analysis of Toll Roads. Transport Reviews, Vol. 35, No. 2, 2015, pp. 140-161.

29. Carbonara, N., N. Costantino, L. Gunnigan, and R. Pellegrino. Risk Management in Motorway PPP Projects: Empirical-based Guidelines. Transport Reviews, Vol. 35, No. 2, 2015, pp. 162-182.

30. Roumboutsos, A., and A. Pantelias. Allocating Revenue Risk in Transport Infrastructure Public Private Partnership Projects: How it Matters. Transport Reviews, Vol. 35, No. 2, 2014, pp. 183-203.

31. Bagloee, S. A., M. Kermanshah, and C. Bozic. Assessment of Public-Private Partnership in Traveler Information Provision. Transportation Research Record: Journal of the Transportation Research Board, Vol. 2394, No. 1, 2013, pp. 19-29.

32. Abdel-Aty, M. Modeling Incident-Related Routing Decisions By Using a Nested Logit Structure. In Transportation Research Record: Journal of the Transportation Research Record, No. 1645, Transportation Research Board of the National Academies, Washington, D.C., 1998, pp. 103–110.

33. Polydoropoulou, A., M. Ben-Akiva, A. Khattak, and G. Lauprete, Modeling Revealed and Stated En-Route Travel Response to Advanced Traveler Information Systems. In Transportation Research Record: Journal of the Transportation Research Board, No. 1537, Transportation Research Board of the National Academies, Washington, D.C., 1996, pp. 38–45.

34. Khattak, A. J., Y. Yim, and L. Stalker. Does Travel Information Influence Commuter and Noncommuter Behavior? Results from the San Francisco Bay Area TravInfo Project. . In Transportation Research Record: Journal of the Transportation Research Board, No.1694, Transportation Research Board of the National Academies, Washington, D.C., 1999, pp. 48-58.

35. Yim, Y., A. J., Khattak, and J., Raw. Traveler response to new dynamic information sources: analyzing corridor and area-wide behavioral surveys. In Transportation Research Record: Journal of the Transportation Research Board, No. 1803, Transportation Research Board of the National Academies, Washington, D.C., 2002, pp. 66–75.

36. Vasudevan, M., and K. E. Wunderlich. Quantifying Reductions in Commute Disutility from Traveler Information Services. In Transportation Research Record: Journal of the Transportation Research Record, No. 2000, Transportation Research Board of the National Academies, Washington, D.C., 2007, pp. 51–58.

37. Wang X., A. Khattak, Y. Fan, Role of dynamic information in supporting travel behavior changes: A two-stage travel decision process. In Transportation Research Record: Journal of the Transportation Research Record, No. 2138, Transportation Research Board of the National Academies, Washington, D.C., 2009, pp. 85–93.

38. Kattan L., K. M. N. Habib, N. Shahid and I. Tazul. Modeling Travelers' Response to Incident Information Provided by Variable Message Signs in Calgary, Canada. In Transportation Research Record: Journal of the Transportation Research Record, No. 2185, Transportation Research Board of the National Academies, Washington, D.C., 2010, pp. 71–80.

39. Khattak, A., A. M. Polydoropoulou, and Ben-Akiva M. Modeling revealed and stated en-route 33 travel response to advanced traveler information system. In Transportation Research Record: Journal of the Transportation Research Board, No. 1537, Transportation Research Board of the National Academies, Washington, D.C., 1996, pp. 46–54.

40. Walton, M, Persad K. and Z. Wang. Use of Traveler Information to Improve Texas Transportation Network Operations in the Context of Toll Roads. Center for Transportation Research. The University of Texas at Austin and the Federal Highway Administration. FHWA/TX-07/0-5079-1, 2006.

41. Vasudevan, M., K. Wunderlich, J. Larkin, and A. Toppen. Comparison of Mobility Impacts on Urban Commuting: Broadcast Advisories Versus Advanced Traveler Information Services. In Transportation Research Record: Journal of the Transportation Research Record, No. 1910, Transportation Research Board of the National Academies, Washington, D.C., 2005, pp. 38–45.

42. Kattan, L., K.M.N., Habib, I., Tazul, and N., Shahid. Information provision and driver compliance to advanced traveller information system application: case study on the interaction between variable message sign and other sources of traffic updates in Calgary, Canada. Canadian Journal of Civil Engineering, Vol. 38, No.12, 2011, pp. 1335-1346.

43. Mahmassani, H.S., and G.L. Chang. Dynamic Aspects Of Departure Time Choice Behaviour. In A Commuting System: Theoretical Framework And Experimental Analysis. In Transportation Research Record: Journal of the Transportation Research Board, No.1037, Transportation Research Board of the National Academies, Washington, D.C., 1985, pp. 88-101.

44. Mannering, F., S. G. Kim, W. Barfield, and L. Ng. Statistical Analysis of Commuters' Route, Mode, and Departure Time Flexibility. Transportation Research C, Vol. 2, No. 1, 1994, pp. 35–47.

45. Peeta, S., J.L. Ramos, and R. Pasupathy. Content of variable message signs and on-line driver behavior. In Transportation Research Record: Journal of the Transportation Research Board, No.1725, Transportation Research Board of the National Academies, Washington, D.C., 2000, pp. 102-108.

46. Dia, H. and S., Panwai. Evaluation of discrete choice and neural network approaches for modelling driver compliance with traffic information. Transportmetrica, Vol 6 No 4, 2010, pp. 249-270.

47. Mahmassani, H., and Y.-H. Liu. Dynamics of Commuting Decision Behavior Under Advanced Traveler Information Systems. Transportation Research C, Vol. 7, 1999, pp. 91–107.

48. Caplice, C., and H.S. Mahmassani. Aspects of commuting behavior: Preferred arrival time, use of information and switching propensity. Transportation Research Part A, Vol. 26, 1992, pp. 409-418.

49. Kim, K.S. and U. Vandebona. User requirements and willingness to pay for traffic information systems Case Study of Sydney Australia. In Transportation Research Record: Journal of the Transportation Research Board, No. 1694, Transportation Research Board of the National Academies, Washington, D.C., 1999, pp. 42–47.

50. Peirce, S., and J. Lappin. Acquisition of Traveler Information and its Effects on Travel Choices: Evidence from a Seattle-Area Travel Diary Survey.2003. www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/13813.html. Accessed Nov. 2008.

51. Hyman, W A; Ames, M, Frischkorn, M, Lobdell, K, Aldrete, R, D. Villar. Methods To Enhance Public/Private Partnerships For ITS In Wisconsin, National Technical Information Service, Final Report, SPR-0092-45-11, 2000

52. Yao, W. Applying public private partnerships to the provision of intelligent transport systems. PhD Dissertation, University College London, 2012.

53. Polydoropoulou, A., Gopinath, D. A., and M., Ben-Akiva. Willingness To Pay for Advanced Traveler Information Systems SmarTraveler Case Study. In Transportation Research Record: Journal of the Transportation Research Record, No. 1588, Transportation Research Board of the National Academies, Washington, D.C., 1977, pp. 1–9.
54. Burgess, L. Toppen, A., and P., Pretorius. Real-Time Traveler Information Services Business Models: State of the Practice Review, Federal Highway Administration, FHWA-HOP-07-115, 2007.
55. Crawford, D. Mixed results for public-private traffic management partnerships. ITS international, Route One Publishing Ltd, UK, Accessed by July 2012.
56. Li, C., Public-Private Partnerships in Advanced Traveler Information System Deployment. NATMEC Conference, Madison, Wisconsin. 2000.
57. Lingham, V.R. Striking a Balance: A Policy Analysis of Public Private Partnerships in Advanced Traveler Information Systems CD-ROM. Transportation Research Board of the National Academies, Washington, D.C., 2008, (08-2683).
58. Falcocchio, J.C. R.K. Patel. Advanced Traveler Information System (ATIS) Implementation and Integration Task 11: Evaluation Report, New York Department of Transportation, 2007.
59. Yim, Y.B. Atis, Alternative Revenue Approaches. University of California at Berkeley, PATH research report; UCB-ITS-PRR-2001-4, 2001.
60. Orski, C.k. Traveler Information Services: Sorting Out the Public and Private Sector Roles. National Transportation Operations Coalition (NTOC). Newsletter of the
61. ITS Cooperative Deployment Network. http://www.ntoctalks.com/ko_tis.html. Accessed by July 2010.
62. Guasch, J. L. Granting and Renegotiating Infrastructure Concessions: Doing it Right. Washington, DC: World Bank Institute. 2004.
63. Flyvbjerg, B., M. Holm, and S. Buhl. How (In) accurate are Demand Forecasts in Public Works Projects? Journal of the American Planning Association, Vol 71, No. 2, 2005, pp.131–146.
64. Jackson, D.D. An Evaluation Of Public-Private Partnership Strategies Within The Traveler Information Services Market. In Compendium: Graduate Student Papers on Advanced Surface Transportation Systems. Texas Transportation Institute, Texas A&M University System, 1998.
65. NCPPP, The National Council for Public-Private Partnerships, http://www.ncppp.org, Accessed By Oct 2012
66. Tehran Traffic Control Center, Tehran Traffic Control company (TTCC), Tehran municipality, http://trafficcontrol.tehran.ir/Default.aspx?tabid=108&ArticleId=74, Accessed by Oct 2012.
67. Online Speed Map, Tehran Traffic Control company (TTCC), Tehran municipality, http://www.tehrantraffic.com/trafficmap/map.asp, Accessed by July 2012.
68. Radio-Payam, IRIB; Islamic Republic of Iran Broadcasting, http://www.radiopayam.ir/, Accessed by July 2012.
69. Hajeb, S., Parvizi, P. and F. Norouzi Fard, Safe Lines to Transit in Tehran's BRT. In International Journal of Science and Engineering Investigations, Vol. 1, No. 1, 2012 pp.113-118.
70. Parvizi, P. and S., Mohammadi. Intelligent BRT in Tehran. In World Academy of Science, Engineering and Technology, Vol. 59, 2011, pp.1887-1890.
71. Crochet, J.C., and B., Menon, Technical Assistance and Study Program in Urban Transport Islamic Republic of Iran; Draft Report On Traffic Management And Public Transport In Tehran. World Bank, 2005
72. Sheffi, Y. The Resilient Enterprise: Overcoming Vulnerability for Competitive Advantage. MIT Press, 2005.
73. Information Technology (IT) in Iran, IT news website, Receiving Traffic RDS from Radio-Payam, http://itiran.com/?type=news&id=10065, Accessed by October 2012.
74. Irani mobile, Tehran online traffic map on cell phones. http://www.iranimobile.com/iran-mobile-news/154-2010-04-13-08-36-53.html. Accessed by October 2012

iRAP SAFER ROADS INFRASTRUCTURE BONDS: THE MISSING METRIC FOR SOCIAL IMPACT WORLDWIDE

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ABSTRACT

The iRAP star ratings and safer road investment plans provide the required metrics that can make a social impact bond a reality for all stakeholders including government, industry and the finance sector. The concept has global recognition as a viable solution.

The key components of an iRAP Safer Road Infrastructure Bond include:

- Government sets a road safety performance target
- The iRAP Safer Road Investment Plan provides a measure of the expected lives and serious injuries saved, the crash cost saving and the internal rate of return of all potential road engineering improvements
- Accelerated financing of safety upgrades
- The government / private sector financiers are delivered 20-30 year dividend streams that capture safety performance benefits
- Government / stakeholders celebrate each upgraded section through the promotion of before and after star ratings
- Lives are saved

THE NEED FOR INCREASED INVESTMENT IN SAFER ROADS

Investment in safer roads is many magnitudes smaller than the size and cost of the global fatal and serious injury crash epidemic. Understanding potential reasons for this under-investment can help unlock the necessary resources to ensure 2011-2020 is a Decade of Action for Road Safety as decreed by the United Nations.

The concept of Social Impact Bonds or Social Benefit Bonds are being utilised to accelerate investment in other government sectors such as prisoner reform. This paper seeks to explore the potential for private sector interest in leading a step-change in road safety performance of road infrastructure across the world and how that can be applied. The broad concept is summarised as:

- Private Sector, Investment Fund or Treasury direct accelerated financing of safety upgrades (Social Impact Bond)
- Investments and economic benefits guided by a combination of iRAP Safer Road Investment Plans or similar mechanisms and actual crash analysis
- Benefits measured by before and after Star Ratings and estimated Fatality Reductions
- Results and availability payments calibrated against actual crash data, insurance and hospital records based on stakeholder agreements
- 20-30 year dividend streams that capture and share road safety performance benefits are payable as part of the financing mechanism
- Rapid implementation of safer roads that significantly reduce death and serious injuries on the global road network is enabled.

The need

Road crashes kill 1.23 million people a year. An estimated 30-50 million people are injured every year. Road crashes impact the young and economically productive and impose a significant burden on health, insurance and legal systems.

TABLE 1: The cost of global road crashes (2010 figures)

IRAP ESTIMATE OF THE COST OF GLOBAL ROAD CRASHES IN 2010 (USD)					
Income Group	# of Countries	Fatalities	Annual Cost of FSI Crashes	GDP (IMF, 2010)	% of GDP
Low	33	128,022	$ 17.478 B	$ 401.966 B	4.3%
Lower Middle	49	494,425	$ 204.514 B	$ 4.410 T	4.6%
Upper Middle	47	509,299	$ 778.583 B	$ 15.375 T	5.1%
High	49	94,181	$ 850.810 B	$ 42.206 T	2.0%
TOTAL	**178**	**1,225,927**	**$ 1.851 T**	**$ 62.394 T**	**3.0%**

The cause

Road infrastructure has unacceptable risk of head-on, run-off road, intersection and pedestrian deaths and injuries built in to current designs. Proven and cost effective solutions exist for most crash outcomes and all that is missing is the appropriate scale of response to the problem.

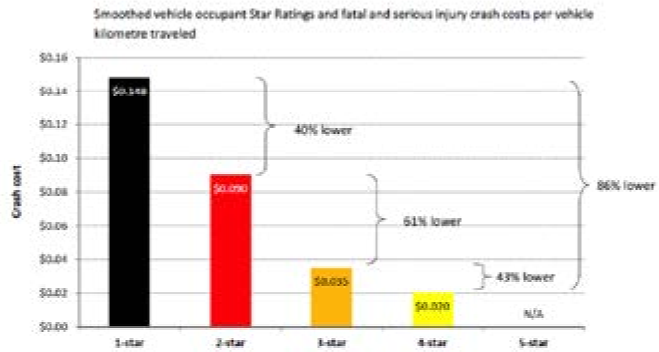
The gross underfunding of road infrastructure safety relates to the disconnection and incorrect apportionment of funds between prevention and funding of consequences.

An analysis of roads star rated by iRAP globally (120,000 km covering more than 20 countries) has identified that over 50% of roads are only one- or two-star standard (out of a possible five-stars where five-star is the safest) for pedestrians, cyclists, motorcyclists and vehicle occupants (3).

The most recent analysis comparing the cost of road crashes per kilometre travelled on each star rating category is detailed in the chart below based on Australian research (4). Similar studies and relationships have been found in other global studies (5).

FIGURE 1: Proportion of roads assessed by iRAP that are at one- or two-star standard (3)

FIGURE 2: The crash cost per vehicle kilometre travelled by star rating (4)



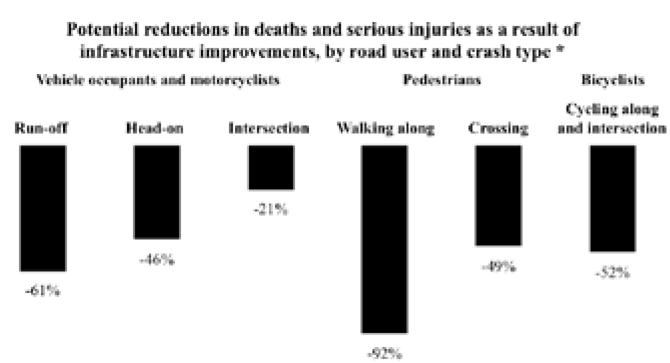
The solution

The preventative solutions for road death and injury are primarily in:

- Road infrastructure (e.g. proven road safety interventions exist for all major road crash types such as footpaths, safe crossings, roadside hazard treatments, median barriers and separation on high-speed roads and roundabouts and intersection treatments).
- Policing and behaviour change (e.g. enforcement, education, technology improvements such as alcohol interlocks)
- Vehicles (e.g. rapid modernisation of fleets to 5-star safety levels)

The iRAP Road Safety Toolkit (http://toolkit.irap.org) was developed in partnership with FIA Foundation, Road Safety Fund, Austroads, ARRB, gTKP/IRF and the Global Road Safety Facility and provides details of many of these interventions and an indication of their effectiveness in reducing crashes based on global research.

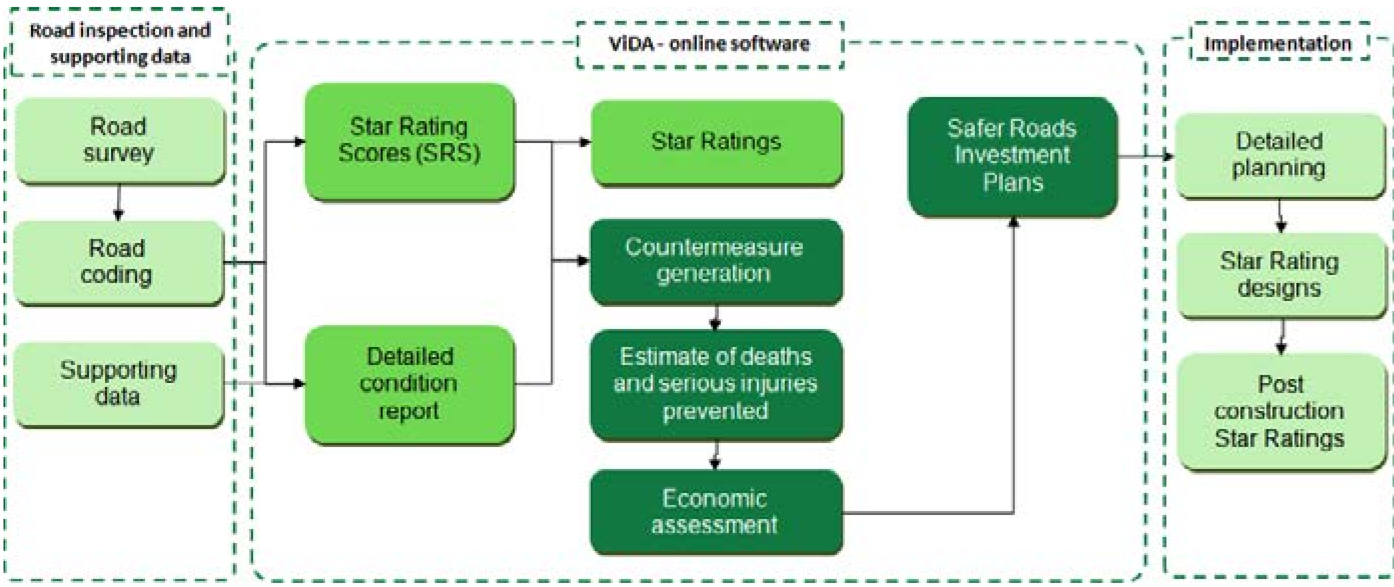
FIGURE 3: Fatality prevention potential of road upgrades *(7 countries and 60,000km of road)



THE IRAP STAR RATING AND SAFER ROAD INVESTMENT PLAN

The iRAP Star Rating and Safer Road Investment Plans have been developed and refined by the world's leading research agencies (ARRB in Australia, MRIGlobal in the USA and TRL in the UK) with contributions from leading road agencies and road safety partners worldwide (e.g. Swedish National Road Administration; the Dutch Ministry of Transport; National Roads Authority, Republic of Ireland; Austroads; New Zealand Transport Agency and leading automobile associations). The models are governed by a Global Technical Committee that also includes RIOH (China), MIROS (Malaysia) and IMT (Mexico) in addition to the development team members above.

FIGURE 4: The iRAP process



The star rating of roads

Star Ratings involve an inspection of road infrastructure attributes that are known to have an impact on the likelihood of a crash and its severity. Between one and five-stars are awarded depending on the level of safety which is 'built-in' to the road.

The safest roads (four- and five-star) have road safety attributes that are appropriate for the prevailing traffic speeds. Road infrastructure attributes on a safe road might include separation of opposing traffic by a wide median or barrier, good line-marking and intersection design, wide lanes and sealed (paved) shoulders, roadsides free of unprotected hazards such as poles, and good provision for bicyclists and pedestrians such as dedicated paths and crossings.

The least safe roads (one- and two-star) do not have road safety attributes that are appropriate for the prevailing traffic speeds and road users. These are often single-carriageway roads with relatively high posted speed limits, frequent curves and intersections, narrow lanes, unsealed shoulders, poor line markings, hidden intersections and unprotected roadside hazards such as trees, poles and steep embankments close to the side of the road. They also typically do not adequately provide for bicyclists and pedestrians with the use of footpaths, bicycle paths and safe crossings.

The safer road investment plans

The Safer Roads Investment Plans build on the Star Ratings to provide a cost-effective, network-wide countermeasure concept plan for implementation by local stakeholders and funding bodies. Safer Roads Investment Plans are generated at the network level as follows:

- The existing condition of the road (star ratings and road attribute data) is used to trigger potential treatments that can reduce death and injury
- The number of deaths and serious injuries that occur on each section of the existing road is estimated (the iRAP process can work with or without detailed crash data)
- An estimate of the crash risk after treatment and the associated economic benefit of the treatment is calculated (including net present value, benefit cost ratio, internal rate of return) and any hurdle rates applied (e.g. BCR > 3, IRR > 12)
- The treatments are optimised (best version of any economically viable treatments are confirmed) and

the impact of multiple countermeasures at a single location are accounted for

- The final Safer Roads Investment Plan is presented to help guide planning activities along the route prior to finalisation of a construction plan.

Together the iRAP Star Rating and Safer Road Investment Plans can provide the mechanism for the whole of government / system benefits to be captured and the rightful, accelerated investment in safer road infrastructure delivered.

THE BENEFITS OF SAFER ROADS

While Prime Ministers and Presidents can directly recognise the whole of government benefits of investment in safer road infrastructure, initial capital funding constraints can and have restricted the scale of investment needed for the long term benefits to be realised. With fatal and serious injury road crashes costing US$1,850 billion each and every year the annual benefits to be unlocked are significant.

A mechanism is needed that adequately informs the funding of road improvements and distributes the potential benefits of this road safety investment to the agencies and actions that have the potential to stop the death and injury occurring. The use of the global iRAP Star Ratings and Safer Road Investment Plans provides one potential mechanism.

Community, technical, financial and political benefits

There is no greater reward than saving lives. Despite the death and injury of an estimated 30-50 million people each year globally the scale of road upgrades to eliminate death and injury is still slow and small in scale. The United Nations has declared 2011-2020 the Decade of Action for Road Safety and the iRAP Safer Road Infrastructure Bonds have the potential to unite the key stakeholders who can make sure it is a Decade of Action.

Community win

High return road infrastructure improvements can typically save at least 1 in every 2-3 fatalities and injuries on high-risk roads. The reduction in personal suffering will be enormous. The individual financial impact of road trauma on families will be significantly reduced.

Technical win

Road authorities will benefit from an increased safety level across their road networks driven by a robust, internationally recognised methodology with backing of the world's leading research agencies. The use of minimum star rating specifications for new roads will provide the "safety pass-mark" for new infrastructure and promote innovation and ingenuity in the road design profession. Road funding levels will be at appropriate increased levels.

Political win

Use of the iRAP star rating protocol will provide the ability to immediately measure the before and after star rating of any upgraded section. The new upgrade, small or large, can be celebrated as the auto-club and government stand together to ribbon cut the road going from one star to three star – or two star to four star immediately upon completion. This will drive community knowledge, interest and demand for further improvements.

Health and legal sector win

The direct costs associated with the long term treatment of head, spinal, limb and internal injuries sustained in road crashes will be immediately reduced. Hospital beds and medical resources will be freed up and waiting lists reduced. Third party insurance costs will be reduced and the legal costs associated with coronial inquiries and crash investigation will be reduced.

Financial win

The iRAP Safer Road Investment Plan provides the objective data to guide the road investment priorities, the returns on investment and the immediate dividend payment stream associated with any accelerated road investment. Pension funds and other sovereign wealth funds interested in reliable capital returns will have a positive and safe infrastructure investment vehicle for client funds. As an international model now applied in 70+ countries worldwide, the iRAP plan will provide confidence to investors and government involved in the initiative. Benefits will accrue over 20+ years providing guaranteed income streams and returns to support the upfront capital investment.

Economic win

The 2-5% of GDP burden on economies will be reduced freeing up resources to focus on poverty reduction, health, education and other sectors essential for sustainable growth.

Measurement of the benefits

A major barrier to investment in road safety in the past is that the impacts are not immediately measurable unless large scale upgrades have been undertaken. The highly effective interventions such as roadside barriers, widening, delineation and intersection improvements need to monitored over time to measure improvements.

IRAP SAFER ROAD INFRASTRUCTURE BONDS

The key steps involved in a Safer Road Infrastructure Bond are provided below with examples presented from a variety of countries. A full case study is currently under development with full public release of the analysis expected soon.

The iRAP Safer Road Infrastructure Bond concept can be led by Treasury, Development Bank or the relevant Transport and Road Department in the country, or be initiated by the industry through innovative financing initiatives. Agencies can undertake iRAP assessments themselves or use the established iRAP accredited supplier networks.

The New Zealand Transport Agency has specified minimum four-star standard for Roads of National Significance in their latest road safety action plan (14). The Vietnam Government has specified no one or two star roads by 2020 in the National Road Safety Strategy and the Swedish and Paraguay Government also have priorities to eliminate one-or two star roads.

The performance target for an individual road can therefore be linked to a government policy target, or alternatively to the strategic importance, crash history, traffic and vulnerable road user volumes and/or functional needs of the corridor.

The iRAP Safer Road Investment Plan provides a measure of the expected lives and serious injuries saved, the crash cost saving and the benefit cost ratio and internal rate of return from the potential application of over 90 proven countermeasures every 100 metres along the road.

The iRAP Safer Roads Investment Plan provides an initial indication of the life-saving engineering improvements that are cost effective along the route. The model is driven by objective road attribute data such that the impact of the individual treatment options can be directly measured. Site specific analysis can be analysed and reviewed by engineering teams.

An extract of an iRAP Safer Roads Investment Plan from the SCT (road authority) assessment of 45,000km+ in Mexico is provided below that highlights the potential to save 7,823 deaths and serious injuries over 20 years with an initial capital investment of 1,217 million pesos (US$ 98 million) with a BCR of 7.2. The Internal Rate of Return for most treatments is well in excess of 30%.

TABLE 2: Safer Roads Investment Plan Mexico 2012 (Mex Pesos)

Total FSIs Saved	Total PV of Safety Benefits	Estimated Cost	Cost per FSI Saved	Program BCR
7,823.87	8,770,317,651	1,217,460,252	155,609	7.20

Countermeasure	Length / Sites	FSIs Saved	PV of Safety Benefit	Estimated Cost	Cost per FSI Saved	Program BCR
Roadside barriers: passenger side	174.20 km	2,452.82	2,749,541,832	439,614,935	179,228	6.25
Roadside barriers: driver side	94.50 km	1542.33	1,728,909,517	236,627,103	153,421	7.31
Duplication with median barrier	52.40 km	1047.66	1,174,398,428	230,760,000	220,262	5.09
Shoulder rumble strips	218.70 km	719.91	807,002,459	17,588,812	24,432	45.88
Street lighting (intersection)	211 sites	310.00	347,504,021	10,357,584	33,411	33.55
Shoulder sealing driver side (>1m)	92.80 km	297.77	333,786,836	55,160,00	185,246	6.05

(525km road section from 45,000km SCT road authority assessment – disc rate 12%)

Accelerated financing of safety upgrades is undertaken and supported by Treasury direct (through recognition of whole of government benefits) or through a Social Impact Bond where the private sector invest in the initial capital investment and/or maintenance programs

An essential element of the accelerated funding is the recognition and capture of the benefits that accrue to other sectors when road infrastructure investments are completed. For example the Bureau of Transport and Regional Economics (15) reported the following breakdown of costs associated with road crashes in Australia.

Undertaking an initial estimate of the likely proportion of each cost category that will be recoverable in terms of actual savings is demonstrated in the table below. It is noted that this area of Social Impact Bond cost capture requires additional research to ensure reliable and cross-government acceptable estimates of savings and where they can be captured for each country. An active study is underway with Treasury and Health officials in Australia with results expected in early 2014.

TABLE 3: BITRE Road crash costs and iRAP Social Impact Bond estimates (AUD)

Cost Type	Value $m	% Recoverable	SIB Recoverable Value $m	Comments
Human costs: output losses	5,690	30%	1,707	Tax revenue, business efficiency, GDP contribution.
Human costs: non-pecuniary	1,864	0%	-	Non-monetary costs.
Human costs: disability costs	1,768	100%	1,768	Full costs averted. Benefit share with health and social security system expected.
Human costs: medical and other	864	100%	864	Full costs averted. Benefit share with health and social security system expected.
Human costs: other	794	0%	-	Assume costs not recoverable.
Vehicle costs: repair cost	4,227	20%	845	Insurance savings — majority redistributed through competitive pricing to consumers.
Vehicle costs: vehicle unavailability	214	0%	-	Assume costs not recoverable.
Other costs: travel delay, vehicle operation	840	20%	168	Productivity benefits and potential infrastructure availability / lane rental benefits.
Other costs: insurance administration	1,421	80%	1,137	Individual case management costs will drop with reduction in incidents. Some overhead costs remain.
Other costs: other	167	0%	-	
Total	**17,849**		**6,489**	
Percentage of recoverable costs			**36%**	**The proportion of crash costs that can be directly recoverable for the purposes of a Socal Impact Bond or equivalent.**

The individual investments are measured in terms of before and after star ratings, risk maps and the predicted fatality reductions and economic benefits as derived from the iRAP Safer Road Investment Plans.

Income risk profile for capital providers

The government agencies or private sector financiers are delivered 20-30 year dividend streams or availability payments that capture road safety performance benefits as measured objectively by the iRAP model

The provider of the upfront capital to allow the acceleration of road safety improvements is able to access the agreed share of the total annual crash cost saving identified in the iRAP Safer Roads Investment Plan. Utilising the Mexican roadside barriers example above (removing the 12% discount rate for the IRR calculation and assuming the intervention is applied as a mass-action treatment in year 1) the calculated dividend stream would be as follows:

Roadside barriers treatment length	268.7 km
Estimated year 1 capital	MXP 676 million (US $52 million)
Annual benefits:	MXP 600 million (US $46 million)
Percentage of recoverable crash cost savings	36%
Annual divided stream:	MXP 216 million (US $17 million) over 20 years
Internal Rate of Return	32%

RECOMMENDATIONS AND NEXT STEPS

The iRAP Safer Road Infrastructure Bonds are well suited to a road with high crash rates and highly deficient road engineering safety levels or are subject to a public private partnership on an existing or new piece of road. Current feasibility activities include:

- Analysis by Australian Government Treasury officials as part of a potential multi-billion dollar road upgrade of 1,700km of road that currently experiences crash rates 3-5 times greater than other strategically important roads. The road has an estimated 5,000 deaths and serious injuries predicted over the next ten years. The current road is primarily 1,2 or 3 star standard where 4- or 5-star is the preferred target.
- Early discussions related to the reprivatisation of up to 5,000km of road in Mexico currently managed by Banobras that has the potential to include upgrades to minimum 3- or 4-star standard as part of any term sheet.
- Independent review by Deloitte Access Economics and ongoing discussions with a range of government, development bank and investors.
- The feasibility steps above, in addition to ongoing discussions with infrastructure investment groups and pension funds globally will need to confirm the viability of the mechanism prior to wider application.
- If the concept can truly unlock the accelerated high-return investment in safer roads needed to save many lives then the global application of iRAP

Safer Road Infrastructure Bonds can be completed on scale. With more than 50% of world road deaths predicted to occur on less than 10% of the world's roads, global impact can be readily achieved. An investment in safer roads of just 0.25% of GDP per annum per country for a period of ten years will essentially eliminate one- and two-star roads and shift a significant proportion of vehicle kilometres travelled onto four-star or better roads.

- With the concept able to work in low, middle and high-income environments with or without crash data, an entire country or entire continents principal road network can be brought quickly up to minimum 3-star standard and the burden of road death lifted from future generations. Then we will achieve a world free of high-risk roads.

REFERENCES

1. WHO (2013), Global Status Report on Road Safety, www.who.int/safety
2. McMahon, K. & Dahdah, S. (2008) True Cost of Road Crashes, iRAP www.irap.org
3. iRAP (2013), The Road Infrastructure Safety Global Business Case, iRAP www.irap.org
4. McInerney, R. & Fletcher, M. (2013), The Relationship between Star Ratings and Crash Costs on the Bruce Highway, Australia, iRAP www.irap.org
5. iRAP / EuroRAP (2011), Star Rating – Crash Cost Comparisons, iRAP www.irap.org
6. iRAP (2013), Star Rating of Roads: The iRAP Methodology, iRAP www.irap.org
7. iRAP (2013), Safer Road Investment Plans: The iRAP Methodology, iRAP www.irap.org
8. New Zealand Government (2013), Safer Journeys Action Plan 2013-2015, www.saferjourneys.govt.nz
9. BITRE (2010), Cost of road crashes in Australia, http://www.bitre.gov.au/publications/2010/report_118.aspx
10. AusRAP (2013), Star Rating of Australia's National Highway network, www.ausrap.org

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Ministry of Transport
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South African Road Federation
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The **INTERNATIONAL ROAD FEDERATION** is a full-service membership organization founded in Washington, D.C. in 1948. The IRF is a non-governmental, not-for-profit organization with the mission to encourage and promote development and maintenance of better, safer and more sustainable roads and road networks around the world. Working together with its members and associates, the IRF promotes social and economic benefits that flow from well-planned and environmentally sound road transport networks and advocates for technological solutions and management practices that provide maximum economic and social returns from national road investments.

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