Failure Path Analysis with Respect to Private Sector Partners in Transportation Public-Private Partnerships

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Abstract: Innovative public-private partnerships (PPPs) have created potential opportunities for both public and private sector organizations in developing and managing public transportation networks. Through PPPs, public sector agencies are able to overcome budgetary and technical constraints and private sector companies can obtain long-term and sustained business prospects. However, previous studies have noted that despite possessing experience and skills, private sector companies are prone to making serious mistakes that could lead to the failure of a PPP project. Based on extensive case studies, this paper proposes a failure mechanism model that reflects the trails of mistakes made by private sector partners in transportation PPPs. A questionnaire survey was conducted to validate and assess the criticality of the failure drivers in the failure mechanism model and the causal relationships involved. Multiple regression path analysis was then applied to assess the statistical significance and calculate the path coefficients of the causal relationships depicted by the proposed failure mechanism model. This analysis then yielded the path coefficients, which indicate the causal strength of the proposed failure mechanism model along with its statistical significance. Based on the results of multiple regression path analysis, the failure mechanism model was respecified to reflect the validated and statistical significant causal relationships. **DOI:** 10.1061/(ASCE)ME.1943-5479.0000384.

Author keywords: Transportation; Public-private partnerships; Failure mechanism; Multiple regression; Path analysis.

Introduction

Public-private partnerships (PPPs) are project-specific institutional arrangements for facilitating private business activities in public infrastructures. Transportation PPPs are the project delivery frameworks in which public and private sector organizations join hands to build or manage public transportation facilities and thereby share the risks and rewards involved. The innovation of PPPs in the transportation sector has brought opportunities for both public and private sector organizations. Through the PPP procurement models public sector agencies are able to exploit the resources of private sector companies, thereby reducing infrastructure development and management costs and also increasing the efficiency and effectiveness of public transportation networks. On the other hand, PPPs provide private sector companies with an opportunity to achieve long-term and sustained business prospects.

The availability of diversified forms of PPPs has made it possible to develop partnerships for almost all types of transportation systems. However, the build-operate-transfer (BOT) approach remains a popular form of PPP in the transportation sector. In a typical transportation BOT project, private sector companies are invited to develop or rehabilitate and operate public sector infrastructure for a defined time period, commonly known as the concession period, and therefore the private sector partners are also referred to as the concessionaire. In the BOT type of PPP, the concessionaire is responsible for investing most of the construction cost and retaining all the project construction and operation risks. The private sector partners are then compensated through tolls, i.e., user fees, collected during the concession period. Subsidies and ancillary payments are often paid to the concessionaire during the construction and operation of the project. Nevertheless, the revenues generated through the toll collection remain the primary source of profit and debt repayment and are therefore the main motivation for private sector companies to enter in partnerships with public sector agencies.

PPPs encompass extended levels of interaction between public and private sector organizations in which the public sector is required to act as a partner and share equal risks and responsibilities rather than being the mere client as in conventional procurement systems. Similarly, in PPPs the private sector not only enjoys higher freedom and authority to bring innovation and efficiency to the project operations but also retains higher risks than usual and the responsibility of heavy upfront capital investments. Such design and operational freedom and sustained profitable business opportunities with relatively high levels of risks and investments have made the PPP business a difficult endeavor for private sector companies.

Case studies by Soomro and Zhang (2011) showed that in pursuit of sustained and profitable business, private sector companies often make fundamental mistakes (hereinafter called failure drivers) while bidding for transportation concessions and also in constructing and operating the PPP infrastructures. Such failure drivers further unfold into more complex problems not only for the private sector partners themselves but also for other project partners. Following the trails of failure drivers associated with private sector partners through the different project stages and partners, Soomro and Zhang (2013) evaluated a failure mechanism model. The failure mechanism model portrays the flow of the failure drivers originally generated through the actions of private sector partners that lead to partnership failure.

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Note. This manuscript was submitted on January 9, 2014; approved on March 13, 2015; published online on June 1, 2015. Discussion period open until November 1, 2015; separate discussions must be submitted for individual papers. This paper is part of the ***Journal of Management in Engineering***, © ASCE, ISSN 0742-597X/04015031(10)/$25.00.

This paper takes a further step in the discovery of the failure mechanism model by measuring validity and severity of the failure drivers. Such measurements are made possible by means of a structured questionnaire survey of transportation PPP experts all around the world. In addition to the validity and severity assessment, the collected responses are used to demonstrate the causal strength of failure links among failure drivers that in whole constitute a failure mechanism. The causal strength among failure drivers is evaluated through multiple regression path analysis (MRPA), which is a special case of structural equation modelling. MRPA revealed the level of causal effect and its statistical significance across the whole failure mechanism, which further helped in respecifying the failure mechanism model.

Consequences of Transportation PPP Failures

Failure of a transportation PPP project has manifold consequences affecting all stakeholders. The levels of effect on different stakeholders vary with respect to their invested stakes and the nature of the PPP failure. Among the multifarious consequences of a transportation PPP failure, the most evident and immediate is the disruption of services, which directly impact the public users and then the public agency, who is responsible for the restoration of the services or the facilities. In most cases, such a public agency also acts as a partner in failed PPPs. Therefore, irrespective of the private partner's fault, the consequences of a PPP failure eventually fall on the public users and the public partnering agency. One example is Colombia Comino Toll Road, where the roadway was first closed for the public and soon after the concessionaire went bankrupt (Soomro and Zhang 2011). It took almost a year before the government paid the outstanding debt to the financing company and then the road was opened for the public (Samuel 2004). The second example is the Mexico toll road program in which the government had to take over 23 financially troubled and incomplete toll roads (Ashuri et al. 2012; Ruster 1997) by paying $5 billon to the national banks and financial institutions and $2.6 billion to the construction companies to settle outstanding debt (Hodges 2006). Dualaimi et al. (2010) provided a third example of failed transportation projects, the theme park in the United Arab Emirates, due to a lack of rigorous financial standing.

Flawed PPP deals are prone to public protests. In the case of the Skye Bridge in the United Kingdom, which was constructed under a 33-year concession, the enforcement of high tolls was strongly protested by the people of the Isle of Skye. Despite severe punishments to the private participants, public protests continued for 8 years, creating huge political pressure that led the government to buy back the infrastructure at a cost much higher than the original construction cost of the bridge (BBC 2004).

Failed transportation PPPs can also incur huge losses to the private participating companies. In the M1/M15 toll road in Hungary (Joosten 1999), the Bangkok Elevated Road and Train System (Kuranami et al. 2000), and the Novisad Road in Belgrade, Serbia (Carpintero 2010), the transportation facilities built under the PPP scheme were confiscated or the PPP contract was outright terminated without any compensation. In the case of the Colombia Comino Toll Road, a majority of the project land owners were the project investors who lost major chunks of their investments as the PPP failed (Samuel 2004). Similarly, in the case of the Channel Tunnel, a number of investors had to write off their investments due to long delays in construction works, which resulted in huge rise of construction costs and consequent default on bank loan (Castle 2003).

Identification of Failure Drivers and Failure Mechanisms in Transportation PPPs

Soomro and Zhang (2011) studied 35 failed transportation PPPs in developed and developing countries, primarily attempting to identify the underlying phenomenon of transportation PPP failures. To understand the fundamentals of PPP failures, the research identified a variety of failure drivers in transportation PPP projects. Failure drivers are basically factors induced through project partners or external factors that bring negative impacts on the project progress. Failure drivers include improper actions and decisions by project partners, socioeconomic factors, factors associated with political and national situations, and other associated events responsible for transportation PPP failures.

These case studies also revealed the characteristics of failure drivers. It is found that failure drivers have the potential to trigger new failure drivers in simultaneous and/or later project stages. The potency of failure drivers to trigger new failure drivers is not limited to the triggering party but can create new failure drivers in other project partners and in sociopolitical domains. Such characteristics of failure drivers are then explained through the failure mechanism. A failure mechanism is a chain of failure drivers that is initiated with the occurrence of a single failure driver and then keeps triggering new failure drivers in similar and other categorical domains, eventually leading to PPP project failure. The categorical domain refers to the different project partners and project stages. A failure mechanism model, therefore, demonstrates a generic model predicting trails of mistakes and inappropriate decisions in the context of transportation PPP projects by private sector partners.

Failure Mechanisms Initiated by Private Sector Partners

Fifteen failure mechanisms were identified that were triggered through the actions and decisions of the private sector partners and caused project failures. Fig. 1 shows the 15 failure mechanisms consolidated to illustrate the overall trend of the identified failure mechanisms and failure drivers sharing multiple failure mechanisms. In Fig. 1, all failure drivers and the failure status are presented in three rectangular boxes: the top left rectangular box contains the numbers of failure mechanisms passing through each failure driver, the center box contains the name of the failure driver, and the right bottom box contains the party responsible for dealing with the failure driver. An analytical method was employed to select and analyze failed transportation PPP cases. Failure criteria were established at which all failure mechanisms are terminated. The failure criteria are discussed in the following:

- Value for money not achieved: The public sector is unable to achieve value for money and tax payers suffer losses.
- Concession cancelled: The concession contract is cancelled by the government and a new tendering process is launched.
- Concession tender cancelled: The concession tender is called off at an initial stage (i.e., before signing agreement) due to poor financial viability of the project or some other reason, such as political opposition or change of plans and policies.
- Project nationalization: The government nationalizes the project, i.e., the project comes under public ownership.
- Project halted: The project is halted for a long time due to some conflicts, legal proceedings, or technical faults.
- Contract suspension: The government temporarily suspends the concession rights of the concessionaire.

The number of initiating failure mechanisms in each project stage demonstrates the vulnerability of the private sector in that particular stage. For example, triggering 8 out of a total of 15 failure

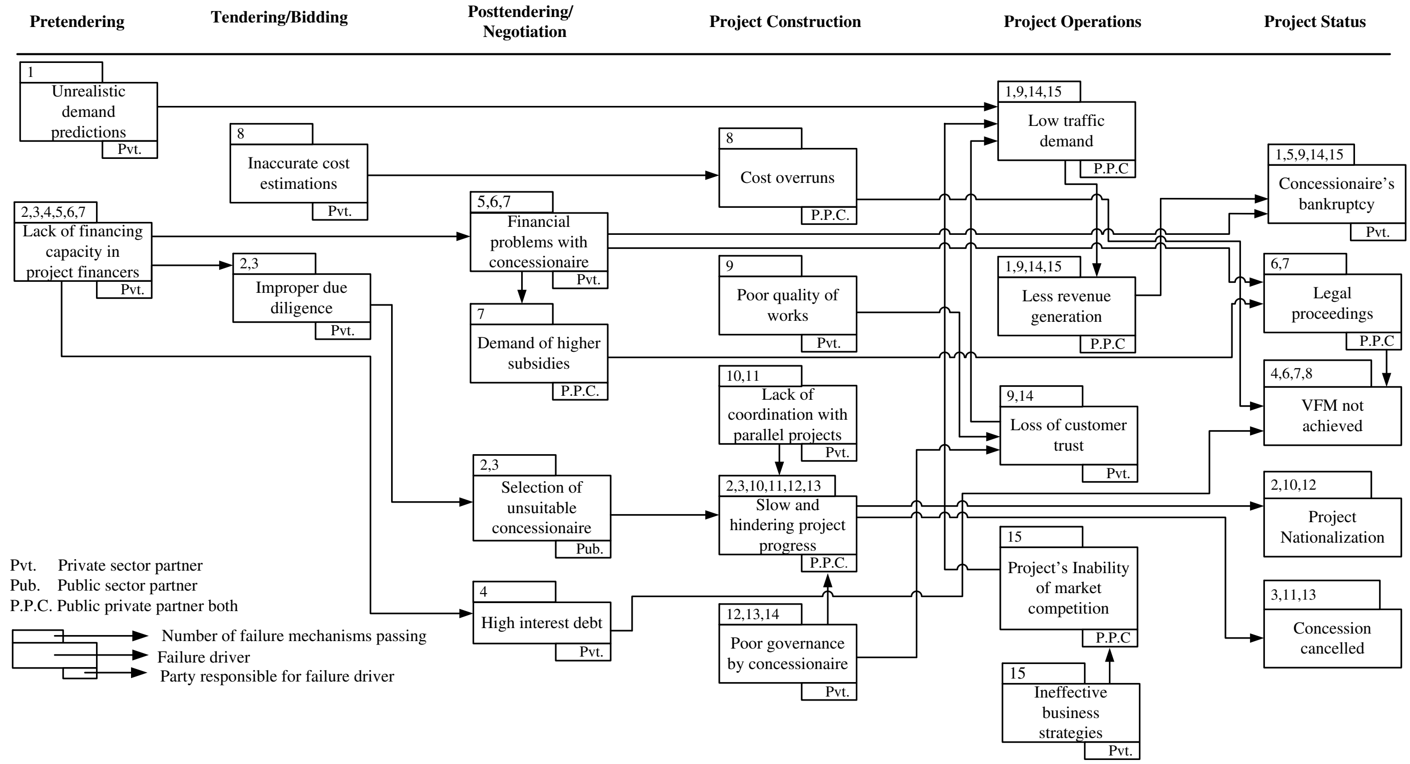

Fig. 1. Failure mechanism model associated with private sector partners

mechanisms in the procurement and tendering stage shows the weakness of the private sector bidders and partners in qualifying for the requirements of these project stages.

In the tendering stage, the failure mechanism model demonstrates the private sector bidders' mistakes in forecasting future traffic flows and estimating construction costs, which ultimately impact the financial viability of the project. Inaccurate cost estimations cause cost overruns during project construction and unrealistic demand predictions lead to low traffic demand. In the majority of transportation PPPs, toll collection from users is vital and it is sometimes the only source of income, and therefore if the traffic demand is lower than the target it will hit hard on the financial viability of the project. The impact of less traffic and the consequent lower revenue generation has been witnessed in the failed PPP projects such as the M1/M15 toll road in Hungary (Joosten 1999) and the Channel Tunnel in the United Kingdom (Castle 2003).

In the construction stage, six failure mechanisms are triggered through the three failure drivers associated with the project management framework of the private sector company. The three primary failure drivers are poor quality of work, lack of coordination with parallel projects, and poor corporate governance of the project company. Lack of coordination with parallel projects and poor governance of the project company impact the pace of the project progress, whereas poor quality of work raises safety issues and causes a decrease in the targeted demand.

The failure mechanism model also illustrates failure drivers on the part of project financers. In usual cases, the financing institutes from international markets have theoretically very large financing capacity, but sometimes due to existing laws and regulations in the PPP project host country the financing market is limited to the national or local financial institutes. Based on the case studies, it is found that local financial institutes, having no or little prior experience of project financing, lack knowledge in rigorous due diligence practices and are often unable to finance long-term projects. The lack of financing capacity of a project financer is found to have initiated at least three failure mechanisms. Failure to comprehend the dynamics of long-term goals leads financing companies to approve unsuitable concessionaires, which are prone to risk of project failure. Such improper assessments had been witnessed in the failed transportation PPP of the Mexico toll road program, where most of the concessions had not reached the maturity level (Ruster 1997). High-interest-rate debt, another indicator of low financing capacity, affects the profitability of private sector investors.

Questionnaire Survey on Failure Drivers in Transportation PPPs

A questionnaire survey was conducted between December 2012 and March 2013 to solicit expert opinion on failure drivers in transportation PPPs. The questionnaire survey attempted to validate the empirically identified failure drivers and to assess their impact on transportation PPP failures. The survey focused on the international transportation PPP market, including PPP practitioners in public sector organizations, toll roads, and mass transit rail operators, PPP consultants associated with international organizations, and PPP researchers from academia. The selection of survey participants from industry was based on an extensive web search that returned a number of potential respondents, depending on their experience, affiliation with transportation PPP businesses, and the positions they hold in their professions. The selection of participants from academia is based on their research publications on transportation PPPs.

A total of 400 potential respondents were selected based on the preceding search criteria; web-based electronic questionnaires were dispatched at the start of December 2012, and the responses were

Table 1. Demographic Profile of Survey Respondents

Experience with PPP projects	Nature of respondents' organization: Academia	PPP supporting agencies	Private sector	Public sector	Total
1–5 years	10	1	2	14	27
6–10 years	6	1	2	7	16
More than 10 years	9	2	2	0	13
Experience not mentioned	6	0	1	1	8
Total	31	4	7	22	64

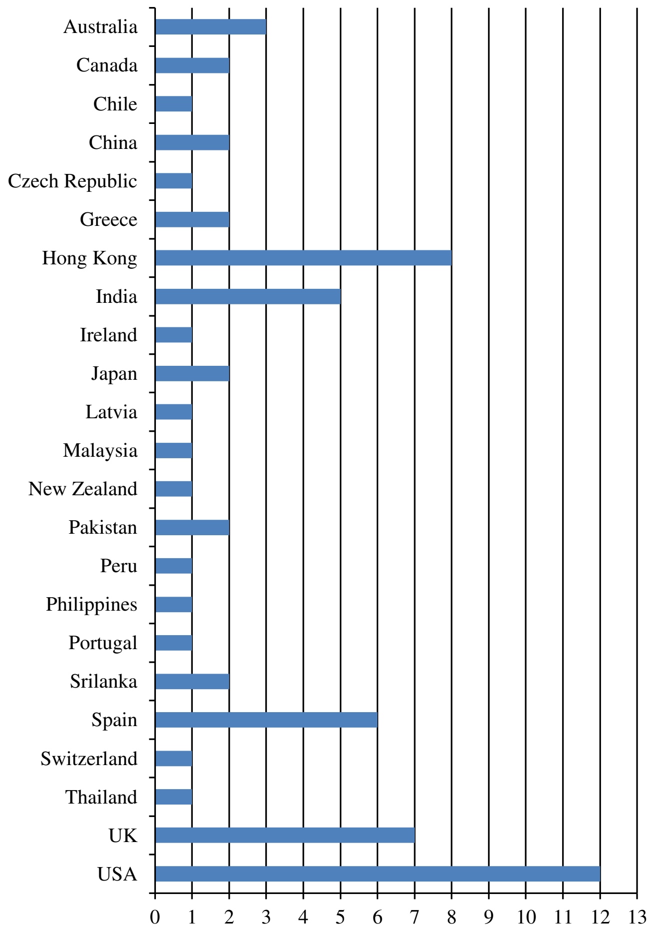

Fig. 2. Geographical distribution of questionnaire survey respondents

collected by March 30, 2013. Table 1 shows the questionnaire survey respondents' profile demographics. The respondents belong to 13 different countries, including advanced economies of the United Kingdom and the United States and developing countries like Latvia, India, and Pakistan. Fig. 2 shows the geographical distribution of the respondents.

Reliability Analysis

Reliability of the questionnaire refers to the repeatability, stability, or internal consistency among variables and the scale being used to measure the variables (Jack and Carke 1998; Rattray and Jones 2005). Cronbach's alpha statistics are used to demonstrate the internal consistency reliability associated with the scores derived from the scale used in the questionnaire. Cronbach's alpha utilizes internal correlations to determine if the questionnaire variables are measuring the targeted domain (Bowling 1997; Bryman and Cramer 1997; Jack and Clarke 1998).

The default value of the Cronbach alpha test ranges between 0 and 1. If the measured scores demonstrate good internal correlations among the variables measured through the questionnaire, the value of Cronbach's alpha test should exceed 0.7; however, Nunnaly and Bernstein (1994) suggested a minimum acceptable value of 0.70. This minimum value suggestion was assessed by Lance et al. (2006), who advised a value of 0.8 as the minimum goal and a value of 0.9 if important decisions are to be made based on the questionnaire findings.

The Software Package for Social Scientists (*SPSS 20*) was used to perform Cronbach's alpha test. The Cronbach's alpha test conducted for the questionnaire responses resulted in a value of 0.973, which demonstrates a high degree of internal consistency and reliability of the questionnaire survey design and the scale used to calculate failure drivers.

Table 2. Agreement Analysis among Survey Respondents

Kendell's concordance test parameter	Academic	PPP supporting agencies	Private	Public
Kendall's *W*	0.194	0.335	0.263	0.116
Chi-square (achieved value)	99.577	25.426	29.941	46.317
Chi-square (critical value)	44.15	25.426	29.91	44.15
Degree of freedom	19	19	19	19
Asymptotic significance	0.000	0.147	0.053	0.000

Agreement Analysis

Kendell's concordance test was performed to assess the agreement among respondents of different groups on their ranking of the failure drivers. Table 2 shows the results of Kendell's concordance test. The asymptomatic significance for the academic and public sector categories is found lower than 0.05. However, the asymptomatic significance for the respondents' categories of PPP supporting agencies and the private sector is greater than 0.05, which may be because of the small sample size, i.e., four and six respondents, respectively, in these categories. Siegel and Castellan (1988) suggested that Kendall's coefficient of concordance is only suitable when the number of attributes are less than or equal to seven. If the number of attributes exceeds seven, a chi-square test can provide a near approximation (Cheung and Chan 2010). Table 2 indicates the chi-square test results and critical values of chi-square at certain degree of freedom. Higher or equal values of the achieved chi-square test compared with the critical chi-square values indicate a sufficient level of agreement among respondents in respective categories.

Validity Index of Failure Drivers

The questionnaire responses are collected on 5-point ordinal scale, representing not applicable as 0, not significant as 1, fairly significant as 2, significant as 3, very significant as 4, and extremely significant as 5. A validity index formula is then developed to assess the validity of failure drivers based on questionnaire responses

$$\mathrm{VI}_i = \left(1 - \frac{\sum R_{i0}}{\sum_{n=1}^{N} R_{in}}\right) \times 100$$

Table 3. Mean Score Ranking of Failure Drivers in Transportation PPPs

Project stage	Failure drivers	Validity index (%)	Mean score	Rank
Project feasibility	Unrealistic demand predictions	96.88	4.203	1
Project procurement and bidding	Inaccurate cost estimations	96.72	3.738	1
	Improper due diligence by the project financers	96.72	3.508	2
	Selecting an unsuitable concessionaire	95.00	3.433	3
	High-interest debt	96.72	3.033	4
	Lack of financing capacity in lenders	93.33	2.933	5
	Demand of higher subsidies and guarantees by the concessionaire	90.16	2.590	6
Project construction and operation	Low traffic demand	94.92	3.763	1
	Less revenue generation	91.53	3.610	2
	Concessionaire's bankruptcy	89.83	3.458	3
	Cost overruns	93.22	3.407	4
	Financial problems with the concessionaire at early stages of project	93.22	3.203	5
	Slow and hindering project construction	94.92	3.102	6
	Project's inability of market competition	88.14	2.949	7
	Ineffective commercial or business strategies	93.22	2.915	8
	Poor quality of works by the concessionaire	94.92	2.915	9
	Loss of customers' trust on services provided by the concessionaire	91.53	2.898	10
	Legal proceedings due to conflicts between project partners	91.38	2.862	11
	Lack of coordination with parallel projects during project construction	93.33	2.847	12
	Poor corporate governance by the concessionaire	91.53	2.695	13

where VI_i = validity index for the ith failure driver; R_{i0} = number of responses as 0 for the ith failure driver; and R_{in} = total number of responses for the ith failure driver. The threshold value of 80% is kept to evaluate the validity of failure drivers, i.e., if any failure driver has a validity index >80%, it is discarded as a nonvalid failure driver.

Table 3 indicates the validity index of the failure driver. Based on the established threshold value, all failure drivers are found to be valid with the highest validity index of 96.88% for unrealistic demand predictions and the lowest value of 88.14% for project's inability of market competition.

Mean Score Ranking of Failure Drivers

The mean score ranking technique (Chan and Kumaraswamy 1996) is applied to convert the questionnaire survey responses into a single value to reflect the mean significance of each failure driver. The mean score of each failure driver is calculated by using the following formula:

$$\mathrm{MS}_i = \frac{\sum(F_i \times \mathrm{RS}_i)}{N}$$

where MS_i = mean score for the ith failure driver; F_i = frequency of response (from 0 to 5) for the ith failure driver; RS_i = rating score (from 0 to 5) given to the ith failure driver by the respondents; and N = number of total responses for the ith failure driver.

Table 3 shows the rankings of the failure drivers after evaluating the mean scores from the survey responses. The failure driver unrealistic demand predictions is found to score the highest mean value of 4.2 among all the failure drivers found active in the category of failure mechanisms initiated by private sector partners.

Out of a total of six failure drivers in the project procurement and bidding stage, the top four scored a mean value more than 3, which represents the criticality of the procurement and bidding stage itself. Selecting an unsuitable concessionaire is the only failure driver associated with public partners in this stage; however, the rest of the failure drives in this category are associated with private sector partners. The three failure drivers, i.e., those ranked second, fourth, and fifth in this category, are associated with project financers and they are almost ranked as significant. The high mean scores of the three failure drivers demonstrate the necessity of having strong project financers with sufficient financial capacity to conduct rigorous due diligence assessment and to develop a robust project finance structure.

The top five most critical failure drivers in the project construction and operation stage are associated with the financial viability of the project, and all of them possess a mean score higher than 3. The top three failure drivers are closely interrelated. Case studies by Soomro and Zhang (2013) indicated that low traffic demand is a major contributor of decreasing project revenue. Because revenue streams are the vital source of project financing, the lower revenue may directly result in a concessionaire's bankruptcy. Surprisingly, the mean score ranking of these three failure drivers is in the order of their actual appearance. The other failure drivers causing low traffic demand, i.e., loss of customer trust and the project's inability of market competition, also have attained mean score values near significant.

The mean score ranking represents a criticality index based on international perspective on the severity of failure drivers to make any transportation PPP a failure. Nevertheless, a localized version of the criticality index can be prepared by adjustments based on territorial conditions.

Path Analysis of the Failure Mechanisms

Path analysis is a statistical technique to assess hypothesized causal relationships among a set of variables. In particular, path analysis examines situations in which several dependent variables act as chains of influence (Striener 1998). In this paper, path analysis is applied to the failure mechanism model hypothesized by Soomro and Zhang (2013) based on the empirical studies of 35 failed transportation PPPs. The main objective of the application of path analysis in this paper is to assess the extent to which the hypothesized causal relationships are statistically significant and to what extent the independent failure drivers can predict the dependent failure drivers.

Logic of Assessing Causality from Questionnaire through Path Analysis

The assessment of causality through path analysis is basically to develop a causal inference. The application of path analysis in management studies requires collecting data on designed instruments commonly known as questionnaires. A questionnaire contains a list of variables, which are rated by individual respondents based on their skills and experience. In a typical questionnaire-based data collection method, each completed survey represents a case. In order to maintain the consistency and quality of the data, it is necessary to present the questionnaire to all respondents under similar conditions and time frames. In such situations, drawing causal inference based on data collected from individuals under similar conditions and in similar time frames requires strong reasoning that can be proven according to certain logic.

The cause and effect, if present in variable data, are inextricably woven together (Meyers et al. 2013). Therefore, the hunt for causality inference in questionnaire survey data actually looks after the correlation between pairs of variables in the collected responses. It is assumed that the respondents have prior knowledge of persisting issues in the transportation PPP framework, and therefore in their responses the correlation between associated failure drivers does exist, irrespective of the rating of the causal relationship itself. For example, if a respondent ranks low traffic demand as a significant failure driver then that respondent probably ranks less revenue as significant or maybe highly significant because the relationship between the two factors is most evident in transportation PPPs. Nevertheless, such rankings vary with respect to the respondent's affiliation and experience. Therefore, the application of path analysis basically looks at such correlations between pairs of variables that have been identified as containing causal relationships. In developing causal inference from questionnaire data, Meyers et al. (2013) added that what is seen in a correlation is covariation to a certain quantifiable extent. The covariation among variables provides a sufficient basis to establish the causal inference. It has been argued that correlation does not prove causality; however the positive correlation does strongly corroborate the causal inference (Meehl and Waller 2002).

Path Analysis Fundamentals

Path analysis is initiated by developing a path diagram of hypothesized causal relationships. This paper utilizes a path diagram (Fig. 1) to illustrate failure mechanisms initiated by the actions of private sector partners in transportation PPPs.

MRPA and the structural model fitting program are commonly used in performing path analysis (Kline 2011). MRPA employs the ordinary least-square method and the structural model fitting program uses the maximum likelihood approach to calculate path coefficients, generally known as beta coefficients (Meyers et al. 2013). This paper adopted the MRPA approach to evaluate the path model due to the fact that ordinary least-square is less sensitive to the sample size compared with the maximum likelihood method. A path model based on the structural model fitting program contains an extra error variable attached to each measured variable, and therefore the number of parameters in such a model is higher. Moreover, the structural model fitting program requires at least 10 cases for each parameter in the model (Suhr 2008). The structural model fitting program analyzes all path models (i.e., all causal relationships) at the same time. Therefore, the number of required samples remains the same throughout the whole analytical process. However, in comparison with the model fitting program, the multiple regression approach breaks the path model into smaller regression equations (e.g., two or three independent variables predicate a single dependent variable). Hence, a reduced number of variables means fewer parameters to be estimated, and consequently a smaller number of cases are required to solve such regression equations. In addition to the utilization of the path model breakdown approach, the multiple regression path analysis assumes only two to three parameters per variable and it does not include a separate error variable for each measured variable. The reduced number of variables and their associated parameters enable the solution of a path model with a relatively smaller sample size. Nevertheless, the statistical significance of the results remains a question while performing path analysis with a small sample size.

Indicators of Causality and Causal Strength in MRPA

Statistical significant path coefficients provide a basic indicator of causality in MRPA. Path coefficients are standardized regression weights known as beta coefficients associated with independent variables in the regression equations. Among all independent variables, the variables with higher values of regression weights demonstrate higher values of causal effect toward dependent variables. However, it remains necessary to evaluate the individual contributions of each independent variable causing a dependent variable.

The squared semipartial correlation (SSPC) is used to assess the individual contributions of each independent variable causing different dependent variables. SSPC reflects the unique contribution of each independent variable in explaining the total variance of a dependent variable. For example, in Table 4, improper due diligence by the project lender is caused by the only independent variable, lack of financing capacity of the project lenders, and therefore its SSPC is equal to the variance explained. However, the case is different in predicting slow and hindered project progress, where three independent variables act as the cause. Nevertheless, the sum of the SSPCs of independent variables is not equal to the total explained variance of slow and hindered project progress. The inequality of sum of SSPCs (0.47) from the total variance explained (0.6) basically indicate that 47% of the variance is explained by the three independent variables independently, with the remaining 13% variance being handled by more than one of them.

Sample Size and Statistical Significance

The statistical significance illustrates whether the correlation indicated by the path coefficients differs from zero. The statistical significance is subjected to the sample size used for data analysis because sampling distributions are likely to change with the size of samples. A larger sample size does not need to achieve higher path coefficient values to reach statistical significance (Meyers et al. 2013). Hence, assessing statistical significance in relatively smaller samples becomes necessary because higher path coefficient values may not appear statistically different from zero correlation.

This study assumed that all causal links are statistically significant at $p \leq 0.05$. The statistical significance of 0.1 depicts that the chance of achieving the path coefficient value, under given degrees of freedom, is less than 10 times out of 100 (Meyers et al. 2013), or it indicates 90% probability of being correct in stating that the variable has effect (Princeton University 2007). Therefore, to maintain the robustness of the results, all causal links having $p > 0.1$ are considered as null.

MRPA Procedure

MRPA is a step-by-step procedure that starts from the last dependent variable in a path model and gradually moves backward until the path coefficients for all dependent variables are calculated. MRPA evaluates the causal effect by means of predicting dependent variables through independent variables acting as the cause in a path model. A dependent variable is one receiving the effects from other dependent and independent variables. Each dependent variable and its predicting independent and dependent variables are

Table 4. Results of Multiple Regression Analysis

Project stages	Secondary failure drivers as cause	Path coefficients	SSPC	Secondary failure drivers as effect	Variance explained
Procurement and tendering	Lack of financing capacity of the project lenders	0.43	0.18	Improper due diligence by the project lenders	0.18
Posttendering and negotiating	Lack of financing capacity of the project lenders	0.32	0.10	Financial problems with the concessionaire	0.103
	Financial problems with the concessionaire	0.48	0.23	Demand of higher subsidies by the concessionaire	0.23
	Improper due diligence by the project lenders	0.56	0.31	Selection of an unsuitable concessionaire	0.31
	Lack of financing capacity of the project lenders	0.64	0.41	High-interest debt	0.41
Project construction	Inaccurate cost estimations	0.56	0.31	Cost overruns	0.31
	Lack of coordination with parallel projects	0.42	0.1	Slow and hindered project construction	0.6
	Selection of unsuitable concessionaire	0.23	0.03		
	Poor governance by the concessionaire	0.25	0.03		
Project operation	Unrealistic demand predictions	0.15[a]	0.02	Low traffic demand	0.28
	Loss of customers' trust on the services provided by the concessionaire	0.2	0.08		
	Project's inability of market competition	0.4[a]	0.03		
	Low traffic demand	0.75	0.57	Less revenue generation	0.57
	Poor governance by the concessionaire	0.5	0.13	Loss of customers' trust on the services provided by the concessionaire	0.49
	Poor quality of construction works	0.26	0.03		
	Noneffective business strategies	0.55	0.31	Project's inability of market competition	0.31
	Financial problems with the concessionaire	0.68	0.14	Legal proceedings	0.41
	Demand of higher subsidies by the concessionaire	−0.08[a]	0.06		
	Less revenue generation	0.31	0.06	Concessionaire's bankruptcy	0.33
	Financial problems with the concessionaire	0.34	0.08		

[a]$p > 0.05$.

evaluated independently. All predictors are considered as independent variables. The following example illustrates the application of the MRPA procedure.

Example

For a failure mechanism path model, as shown in Fig. 1, the path analysis starts from any of the last dependent failure drivers of the failure mechanism, such as concessionaire's bankruptcy, which is the last dependent variable of the 1st, 5th, 9th, 14th, and 15th failure mechanisms. The first MRPA assumes less revenue generation as the independent predictor for concessionaire's bankruptcy. The first analysis yields causal strength, i.e., the beta coefficient, for less revenue generation causing concessionaire's bankruptcy and the variance explained, i.e., the value of R^2 attached with it. Similarly, the second MRPA yields the beta coefficient for low traffic demand causing less revenue generation and its explained variance. The third MRPA attempts to evaluate causal impacts and explain the variance for low traffic demand through the predictors unrealistic demand predictions, loss of customer trust, and project's inability of market competition. Loss of customer trust and project's inability of market competition are dependent failure drivers in the failure model, but MRPA considers them as independent variables contributing causal impacts to low traffic demand. This similar process continues until all dependent failure drivers in a path model are predicted and all path coefficients are calculated.

Path Analysis Results

Prior to performing MRPA, the descriptive values of the causal strength are rated as strong for path coefficient values of 0.6 and above, moderate for path coefficient values from 0.4 to greater than 6, modest for path coefficient values of 0.2 to greater than 0.4, and weak for path coefficient values of 0.01 to greater than 0.2. Due to the small sample size, the limit for link strength strong is held at a lower point of 0.6. A total of 12 multiple regression analyses have been performed to evaluate the failure mechanism model illustrated in Fig. 1. Table 4 shows the MRPA results. Three causal links are found with values of $p > 0.5$ and therefore are considered as null and omitted from the failure mechanism model.

The highest path coefficient value of 0.75 is found for the causal link from low traffic demand to less revenue generation, and the lowest value of 0.25 is found for poor governance by the concessionaire leading toward slow and hindered project progress. The highest value of explained variance achieved is 60% for slow and hindered project progress and the lowest value of 18% is achieved for improper due diligence by the project financers.

This study basically evaluates the failure mechanisms initiated by the private sector partners. However, it is possible that the failure drivers, other than the initiating failure mechanism, are co-caused by factors associated with other project partners and issues. The values of the explained variance somewhat depict the same notion. For example, Table 4 shows that in the project construction stage, slow and hindered project progress is possibly caused by the three other failure drivers. However, these three predictors are only able to explain 60% of the variance of slow and hindered project progress. The remaining 40% of the unexplained variance reflects the presence of other possible factors responsible for it.

In the case of multiple failure drivers causing a single failure driver, the SSPC values demonstrate aspects that can be inferred as indicators of their complexity. For example, in predicting slow

Table 5. Mediating Effects among Failure Drivers

Project stages	Secondary failure drivers as cause	Indirect causal effects	Secondary failure drivers as effect
Posttendering and negotiating	Lack of financing capacity of the project lenders	0.24	Selection of an unsuitable concessionaire
	Lack of financing capacity of the project lenders	0.15	Demands of higher subsidies
Project construction	Improper due diligence by the project lenders	0.13[a]	Slow and hindered project construction
	Lack of financing capacity of the project lenders	0.06[a]	
Project operation	Poor governance by the concessionaire	0.2	Low traffic demand
	Poor quality of construction works	0.12	
	Loss of customers' trust on the services provided by the concessionaire	0.3	Less revenue generation
	Poor governance by the concessionaire	0.15	
	Poor quality of construction works	0.08	
	Lack of financing capacity in project financers	0.22	Legal proceedings
	Lack of financing capacity of the project lenders	0.10	Concessionaire's bankruptcy
	Low traffic demand	0.23	
	Loss of customers' trust on the services provided by the concessionaire	0.09	
	Poor governance by the concessionaire	0.05	
	Poor quality of construction works	0.02	

[a] $P > 0.05$.

and hindered project progress, the predictor independent failure drivers lack of coordination with parallel projects, selection of unsuitable concessionaire, and poor governance by the concessionaire have SSPC values of 0.1, 0.03, and 0.03, respectively. The sum of these SSPC values is 0.16, which shows that only 16% of the explained variance is uniquely contributed by the three predicting failure drivers and the remaining 44% of the explained variance is mutually shared. This situation also indicates the possible complex interrelationships among dependent and predictor independent failure drivers. Similar situations are in predicting the loss of customer trusts and concessionaire's bankruptcy, where a majority of the variance is mutually explained by their predictors.

Assessment of Mediating and Indirect Effects

The direct causal strength between failure drivers is calculated through MRPA. However, a failure mechanism typically consists of more than two failure drivers and it becomes necessary, therefore, to evaluate the indirect causal effects among the failure drivers in the failure mechanism. For example, in the first failure mechanism, unrealistic demand prediction indirectly causes less revenue generation and concessionaire's bankruptcy. In path analysis terminology, indirect effects are known as mediating effects because such effects are caused through mediating (i.e., intervening) variables. The assessment of mediating effects yields the total causal effect of an initiating failure driver on the middle and last failure drivers in a failure mechanism. Meyers et al. (2013) established rules of assessing mediating effects, which are elaborated subsequently with reference to the ninth failure mechanism.

To cause low traffic demand by poor quality of work through the mediating failure driver loss of customer's trust, the following conditions must hold:

- The poor quality of work must significantly predict the loss of customer's trust;
- The poor quality of work must significantly predict the low traffic demand; and
- The loss of customer's trust must significantly predict the low traffic demand.

If any of the preceding conditions does not hold, the poor quality of work cannot indirectly cause low traffic demand through the mediating failure driver loss of customer trust. Table 5 shows the mediating effects among failure drivers. The mediating effects toward a failure driver are calculated by multiplying the path coefficients. For example, the mediating effect of lack of financing capacity of the project lenders toward demand of higher subsidies is calculated by multiplying path coefficients between them, i.e., $0.32 \times 0.48 = 0.15$.

The Aroian test is then performed to assess the statistical significance of the mediating effects. The Aroian test is performed by means of the Preacher and Leonardelli (2013) mediating effects calculator.

Respecification of the Failure Mechanism Model

Meyers et al. (2013) suggested respecifying the model based on the results of MRPA. The model respecification requires reevaluating certain dependent variables to which the effects are omitted due to values of $p > 0.05$. Table 6 shows the results of the reevaluated variables. Fig. 3 shows the respecified failure mechanism path model. All identified causal strengths, i.e., path coefficients, and their established descriptions are illustrated on respective causal links. Three causal relationships having $p > 0.05$ are nullified and shown as dotted lines.

The causal links are not nullified based on the values of path coefficients because all causal links are empirically proven through the case studies. Contrary to the case study observations, the calculated path coefficients only reflect the survey respondents' perspective on causal strengths among the failure drivers. Therefore, even the weaker values of the path coefficients, which are statistically significant at $p \leq 0.05$, do hold the possibility of their causal

Table 6. Changed Path Coefficients in Respecified Failure Mechanism Model

Failure drivers as cause	Path coefficients	Failure drivers as effect	Variance explained
Loss of customers' trust on the services provided by the concessionaire	0.49	Low traffic demand	0.24
Financial problems with the concessionaire	0.64	Legal proceedings	0.40

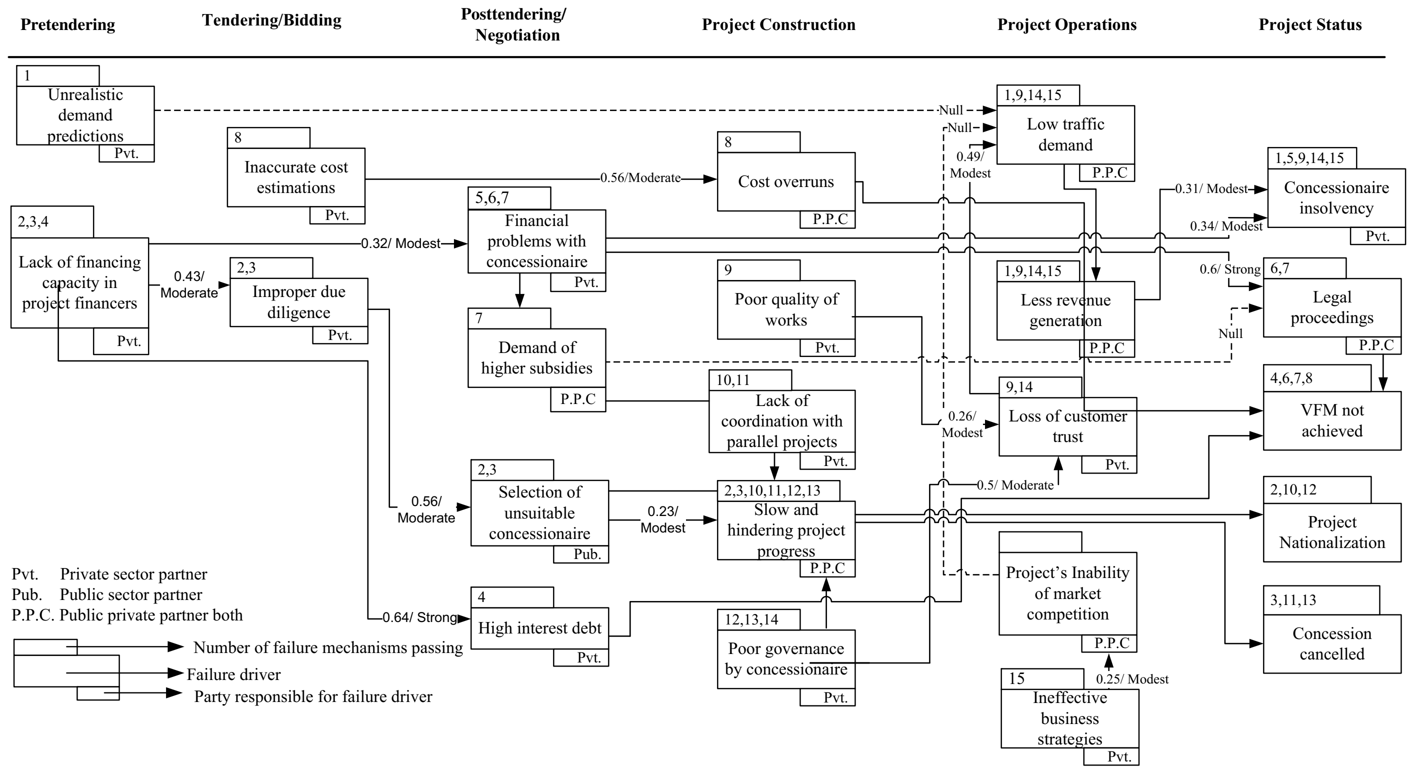

Fig. 3. Respecified failure mechanism model associated with private sector partners

impacts. Therefore, only causal links having $p > 0.05$ are deleted from the failure mechanism model.

The model respecification now requires undertaking MRPA to calculate the path coefficient towards certain dependent variables to whose causal links are removed. Table 6 illustrates the MRPA results performed for such dependent variables.

Conclusions

This paper attempted to evaluate the statistical significance of the failure mechanism model for transportation PPPs through MRPA. A questionnaire survey was conducted to assess the validity and criticality of the failure drivers. The questionnaire survey focused on the international transportation PPP market and included PPP practitioners from both public and private domains, consultants associated with international organizations, and researchers from academia. A validity index was then developed to assess the validity of failure drivers. According to the questionnaire survey results, all failure drivers were found to be valid and their level of significance calculated.

The questionnaire survey responses were used as variable measurements in MRPA, which yielded path coefficients (i.e., indicators of the strengths of the causal relationships among failure drivers). Apart from three causal relationships in the original failure mechanism model, all others were found to be statistically significant. The mediating effects (i.e., indirect causal relationships among failure drivers) were also calculated and assessed for their statistical significance. The failure mechanism model was respecified based on the results of MRPA by removing nonsignificant causal relationships.

The failure mechanism model and its associated causal strengths presented in this paper may act as a benchmark for practitioners, decision makers, and researchers in the field of transportation PPPs while making their decisions and assumptions in the context of transportation PPPs. Because a failure mechanism basically illustrates the impact transmitting paths of the initiating failure driver, it can help predict the outcomes of any doubtful decisions by private sector partners, and therefore it provides public clients a life-cycle check on the private sector partners. Every failure driver in the failure mechanism model acts as a checkpoint to avoid the occurrence of next possible failure drivers and therefore to avoid the whole failure mechanism. The failure mechanism model may be compared with ongoing projects to check for any potential failure drivers and their associated failure mechanisms. Furthermore, because the failure mechanism model presented in this paper predicts the potential outcomes of the actions of private sector partners, it may also help decision makers in deciding on risk allocation among public and private partners.

Acknowledgments

This study is financially supported by the National Natural Science Foundation of China (Project Number: 71472052).

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