Ex-Ante Evaluation of Public-Private Partnerships: Macroeconomic Analysis

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Abstract: Public-private partnerships (PPPs) are currently a popular approach for governments to procure social and economic infrastructure. The macroeconomic environment plays a critical role and influences the factors that can lead to the successful delivery of a PPP project. Despite the importance of the macroeconomic environment, limited attention has been paid to ex-ante (that is, before the event, or forecast) evaluation. A review of the normative literature was undertaken, aiming to derive key performance indicators (KPIs) of PPP success. The KPIs were validated by using a vector error correction model. It is suggested that the developed KPIs can be used to evaluate the suitability of the macroeconomic conditions in which a PPP project will be implemented. These KPIs can provide governments and stakeholders with a platform to conduct an effective ex-ante evaluation of PPP projects that will be significant in policy and decision making. **DOI: 10.1061/(ASCE)IS.1943-555X.0000228.** © *2014 American Society of Civil Engineers.*

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Introduction

Owing to the limited availability of funding for infrastructure development, governments are participating with the private sector to deliver essential services to the community (e.g., health, education, water supply, power, and transport), through the establishment of public-private partnerships (PPPs). Over the past decade, there were many PPP successes and some failures reported in the normative literature (Hodge 2004; Duffield 2005; Regan et al. 2011a, b). The critical factors associated with the success of a PPP project are complex, but a favorable macroeconomic environment has been acknowledged as playing a vital role (Li et al. 2005; Chan et al. 2010).

A stable and favorable macroeconomic condition is the cornerstone for minimizing risks and maximizing the return of investment for a PPP project (Cheung et al. 2012). According to the European Investment Bank (2012), the assessment of macroeconomic environment is an essential part of a PPP ex-ante evaluation. However, despite its importance, limited attention has been paid to develop or refine the core concerns of this critical area (Barretta and Ruggiero 2008). By addressing this gap, this paper aims to contribute to the macroeconomic assessment in ex-ante evaluation of PPP infrastructure projects. Therefore, a set of key performance indicators (KPIs), established to examine the suitability of the macroeconomic environment in which a PPP project is implemented, are derived from the literature; they are empirically validated by using a vector error correction (VEC) model. Such developed KPIs can assist governments and stakeholders to undertake an effective and comprehensive ex-ante evaluation of their PPPs.

The rest of this paper is structured typically and will begin with a review of the normative literature of PPP evaluations. Next, the identification of the KPIs relevant to macroeconomic environment and methodology will be presented. Finally, a series of data and econometric techniques will be used to validate the derived KPIs.

Evaluations of PPP Infrastructure Projects

Project evaluation is a systematic method used for collecting and analyzing information related to the characteristics of the outcome, to improve effectiveness and efficiency (Dart et al. 1998). Generally, there are two kinds of evaluations conducted in construction projects: ex-ante and ex-post evaluation (Regan et al. 2011b). These are also known as formative and summative evaluations, respectively, under program theory (Ainsworth and Viegut 2006), and both are normally applied with the benchmarking approach (Torvatn 1999). At the project level, ex-ante evaluation is a preproject study that is used to offer assistance in investment decision making on the basis of the calculations of feasibility and cost, whereas ex-post evaluation is a comparison between expected outcomes and actual achievements that provides insight into the management of future work (Farbey et al. 1992; Irani et al. 2001, 2005). In practice, ex-ante evaluation is valuable for policy development and supporting project preparation and initiation (e.g., objective definition) and determining project success (European Commission 2001).

Project success is a common objective of all construction projects; it is comprised of two components: product success and project management success (Baccarini 1999). Product success is concerned with the end product, whereas project management

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Table 1. Key Studies of the Cost and Time Evaluations of PPPs

Authors	PPP projects	Traditional lump sum projects
National Audit Office (2000)	Cost: 10–20% savings	N/A
Department for Transport (2002)	Cost: 20% overruns	N/A
Haskins et al. (2002)	Cost: 30–40% savings	N/A
MacDonald (2002)	Cost: 50% savings	Time: 4–39% overruns Cost: 24–66% overruns
Pakkala (2002)	Cost: 14–20% savings	N/A
Fitzgerald (2004)	Cost: 91% on budget	N/A
Liautaud (2004)	Cost: nearly 30% savings	N/A
Auditor-General of New South Wales (2006)	Cost: 7–23% savings	N/A
Allen Consulting Group (2007)	Cost: 11% savings	N/A
Anastasopoulos et al. (2010)	Cost: 4.53% savings	N/A
Raisbeck et al. (2010)	Time: 2.5% overruns Cost: 1.2–11.6% overruns	Time: 2.3% overruns Cost: 13.9–91.5% overruns
Anastasopoulos et al. (2011)	Significant cost savings	N/A

Note: Not all types of PPPs can result in cost savings. For example, warranties are generally expected to cost more than in-house or traditional outsourcing practices but are capable of providing a much better asset performance.

success focuses on the development process and activities (e.g., time, cost, and quality). With this perspective, a plethora of studies have concentrated on ex-post examination with regard to the cost and time performance of PPP infrastructure projects (Haskins et al. 2002; Pakkala 2002; Fitzgerald 2004; Liautaud 2004; Raisbeck et al. 2010; Anastasopoulos et al. 2011). Table 1 summarizes the key findings of the studies that aim to evaluate PPPs through the use of cost and time factors. As shown, PPPs generally display better performance in cost and time savings than traditional lump-sum procurement methods. This is because private sector entities are profit-oriented; therefore, they seek to clearly maximize the cost and time performance of their projects (Yong 2010).

Evaluating PPPs, however, is complicated owing to their long-term and complex nature and the use of single-dimension absolute cost and time assessments cannot fully capture the essence of the delivery of a PPP (Office of Government Commerce 2002; European Commission 2003; Liu et al. 2014). Amos (2004) suggests that ex-post evaluation of a PPP should be expanded to involve the performance indicators of technical and allocative efficiency and financial performance. However, technical and allocative efficiency and financial measures are still insufficient to fully measure PPPs because such important issues as stakeholder satisfaction cannot be addressed in the measurements for technical and financial performance alone (Henjewele et al. 2011). Given the problem of evaluating PPPs, Yuan et al. (2009) proposed an expanded innovative ex-post performance evaluation framework, namely the KPI system. This developed system consists of five measurement aspects: (1) physical characteristics of the project; (2) financial and marketing indicators; (3) innovation and learning indicators; (4) stakeholder indicators; and (5) process indicators.

The majority of the PPP studies concerned with ex-ante evaluation use the public sector comparator (PSC) (Quiggin 2004; Grimsey and Lewis 2004, 2005; Blanc-Brude et al. 2006; Coulson 2008). The PSC has been applied widely across the world, especially in Australia and the U.K., to determine whether a proposed PPP can provide better value for money. Essentially, it is a comparison between the costs of proposed PPP projects and the benchmark cost, which is a cost estimation of the specific service using traditional procurements. Hence, the previous studies focusing on PPP ex-ante evaluation concentrate largely on cost performance (Liu et al. 2014). However, according to European Commission (2001), ex-ante evaluation must be comprehensive, in which economic environment assessment is of primary importance.

KPIs for Macroeconomic Environment Assessment in PPPs

The European Investment Bank (2004, p. 2) defines PPPs as "the relationships formed between private sector and public bodies often with the aim of introducing private sector resources and/or expertise in order to provide and deliver public sector assets and services." The Public-Private Infrastructure Advisory Facility (2014) provides the following definition: a PPP "involves the private sector in aspects of the provision of infrastructure assets or of new or existing infrastructure services that have traditionally been provided by government." According to these definitions, the investment of private sector entities plays a decisive role in PPPs. Akintoye and Skitmore (1994) argue that investment is a derived demand and that the investment of private sector in construction is determined by construction price, domestic economic performance [i.e., gross national product (GNP)/gross domestic product (GDP)] interest rate, purchasing power of population (i.e., unemployment level), and profitability (i.e., manufacturing price), all of which can be indicated as follows:

$$Q^d = f(P, Y, r, U^e, M^p) \tag{1}$$

where Q^d = construction investment (demand); P = construction price; Y = GNP; r = interest rate; U^e = unemployment rate; and M = manufacturing price. In other words, the endogenous factors of Eq. (1) are the macroeconomic KPIs that can be applied to estimate whether the macroeconomic environment is suitable for a construction investment. Detailed explanation about how such aforementioned factors are capable to significantly affect construction investment of private sector can be found in the research conducted by Hillebrandt (1985), Akintoye and Skitmore (1994), and Tse and Ganesan (1997). Because PPPs are construction projects in nature; the indicators displayed in Eq. (1) are also suitable for PPP infrastructure projects.

It is accepted that PPP projects are more complex than traditional lump-sum construction projects, particularly with regard to their financial structure. "PPPs are highly leveraged in listed or private firms and rely on capital markets for both equity and debt capital" (Regan et al. 2011a, p. 7). Most PPP infrastructure projects are financed via bank loans, equity, bonds, or private placements

(Yong 2010). Therefore, any changes in money and capital markets can substantially impact the investment decision of PPPs. Indeed, the impact of changes in the money market on PPPs can be evaluated by examining the interest rate, which has been indicated in Eq. (1). To capture the effect of the capital market on PPPs, a KPI relating to stock and bond market conditions should be involved in ex-ante macroeconomic assessment. Further, Regan et al. (2011a) suggest that the collapse of the global economy had a substantial effect on the development of new and existing PPP infrastructure projects. Considering this perspective, the turbulence of the global economic climate is worthy of inclusion as an exogenous factor in PPP ex-ante evaluation.

Infrastructure normally refers to a technical structure that supports and underpins the growth of a society (e.g., roads, bridges, water and power supplies, hospitals, and prisons) (Infrastructure Australia 2012). As suggested by neoclassical economic theory, the growth of a society is positively related to population growth (Kormendi and Meguire 1985). Hence, population growth should be considered during the investment decision making process of infrastructure development. A report issued by the Victorian Auditor-General (2013) supports this point of view and states that the growth of population is an important indicator of the demand for infrastructure. In the construction literature, several studies (Tang et al. 1990; Goh 1996, 1999; Fan et al. 2010; Jiang and Liu 2011) attempt to incorporate "population" as a macroeconomic indicator into the modeling of residential construction demand, and they discovered a significant relationship between population and residential construction investment.

On the basis of the preceding discussion, the KPIs for the PPP macroeconomic assessment can be summarized as follows: construction price level (P^c), domestic economic conditions (E^d), money market conditions (R), unemployment level (U^e), profitability (PRO), capital market conditions (MC^c), population growth (POP), and global economic climate (E^g). To validate these KPIs, a series of econometric techniques will be applied and the empirical results will be discussed in the following sections.

Methodology and Data

Vector Error Correction Model

The econometric model selected in this paper to validate the aforementioned KPIs is the VEC model. The VEC model is capable of capturing and quantifying the causalities and long-term relationships between variables (Engle and Granger 1987), and possesses a strong ability in construction investment estimation (Jiang and Liu 2011). PPPs are projects with long-term contractual arrangements (Kwak et al. 2009), and the selected KPIs for project evaluation must be causally and significantly related to the outputs and outcomes of the project (Chan and Chan 2004). Thus, the VEC model is suitable for the validation of the derived KPIs.

The form of VEC model is represented as Eq. (2):

$$\Delta Y_t = \alpha \mathrm{ecm}_{t-1} + \sum_{i=t}^{p-1} \Gamma_t \Delta Y_{t-1} + \varepsilon_t \tag{2}$$

where ΔY_t = vector in difference; α = adjustment coefficient; ecm_{t-1} = error correction term reflecting long-run parameters; Γ_t = coefficient matrices; and ε_t = vector of error term.

As discussed previously, global economic turbulence needs to be considered as an exogenous factor in the PPP ex-ante evaluation of the macroeconomic environment. Accordingly, a dummy variable will be inserted into Eq. (2) as an exogenous variable. On the basis of the previously developed KPIs, Eq. (2) can be rewritten as

$$\begin{aligned}\Delta Q^{\mathrm{PPP}} = {} & \alpha \mathrm{ecm}_{t-1} + \sum_{i=1}^{p} \Gamma_{1,i} \Delta Q^{\mathrm{PPP}}_{t-i} + \sum_{i=1}^{p} \Gamma_{2,i} \Delta P^c_{t-i} \\ & + \sum_{i=1}^{p} \Gamma_{3,i} \Delta E^d_{t-i} + \sum_{i=1}^{p} \Gamma_{4,i} \Delta r_{t-i} + \sum_{i=1}^{p} \Gamma_{5,i} \Delta U^e_{t-i} \\ & + \sum_{i=1}^{p} \Gamma_{6,i} \Delta \mathrm{PRO}_{t-i} + \sum_{i=1}^{p} \Gamma_{7,i} \Delta CM^c_{t-i} \\ & + \sum_{i=1}^{p} \Gamma_{8,i} \Delta \mathrm{POP}_{t-i} + \delta E^g_t + \varepsilon_t \end{aligned} \tag{3}$$

where Q^{PPP} = private sector investment on infrastructure using PPPs; δ = coefficient of exogenous variables (dummy variable). The VEC model with dummy variables has been applied in previous studies to estimate the impact of global economic turbulence on the construction and housing sectors in Australia (Jiang and Liu 2011; Liu and London 2013). This paper will primarily examine how the 2008 global financial crisis (GFC) has affected the construction investment within the context of PPPs.

Data Collection

Data applied for empirical estimation were derived from the following sources: Australian Bureau of Statistics (ABS), Reserve Bank of Australia (RBA), and Australian Stock Exchange (ASX). The selected data series cover third quarter 1997 (1997Q3) to first quarter 2013 (2013Q1). The reason for selecting this sample period is the lack of earlier data on construction prices and the absence of most updated data on population size at the national level in Australia. This period also covers the effects of the GFC from 2008 onward.

Investment, as mentioned previously, is a derived demand (Akintoye and Skitmore 1994). Hence, the private sector investment on infrastructure using PPPs can initially be measured by the value of the engineering construction work commenced by the private sector for the public sector in Australia. These data are derived from the ABS and is compiled from the infrastructure work (e.g., roads, highways, water supply, recreation, and electricity generation) procured by PPPs (ABS 2013b). Second, the output producer price indexes (PPIs) of infrastructure construction work (e.g., road, bridges, and highways) and the manufacturing sector are used to reflect the Australian construction price and profitability. Both of these data are issued by the ABS, indicating the changes in the prices of products as they leave production process (ABS 2013d). The manufacturing price is an appropriate proxy for the profitability of the construction investment of private sector; this point of view has been demonstrated by Hillebrandt (1985) and Akintoye and Skitmore (1994).

Third, domestic economic performance, interest rates, unemployment levels, and population can be captured by using the data on the Australian GDP, real interest rates, unemployment rates, and estimated resident population, all of which are published by RBA (2013a, b) and ABS (2013a, c), respectively. Finally, the stock price indexes provided by ASX (2013) are extracted to measure capital market conditions. Prior studies have found a long-term convergence between stock and bond returns (Fama and Gibbons 1982; Stivers and Sun, "Stock market uncertainty and the relation between stock and bond returns," working paper, Federal Reserve Bank of Atlanta, Atlanta, Georgia). Therefore, the stock price index is an ideal indicator of capital market changes.

Table 2. Results of the ADF Unit Root Tests

	ADF unit root tests			
	Level		First difference	
KPIs	T-stat	P-values	T-stat	P-values
Q^{PPP}	−1.39	0.86	−4.81	0.00[a]
P^c	−2.77	0.21	−2.14	0.03[b]
GDP	−2.51	0.32	−2.11	0.03[b]
R	−0.68	0.41	−5.09	0.00[a]
U^e	−1.30	0.88	−4.81	0.00[a]
PRO	−2.17	0.50	−5.24	0.00[a]
CM^c	−2.55	0.30	−5.26	0.00[a]
POP	−1.37	0.86	−4.39	0.00[a]

Note: P-values denote the probability values.
[a]Rejection of null hypothesis at the 0.99 significance level.
[b]Rejection of null hypothesis at the 0.95 significance level.

Empirical Results and Analysis

Unit Root Test and Cointegration Test

The time-series data used for econometric models must be stationary; otherwise, a spurious regression will occur (Granger and Newbold 1974). To test whether the selected data are stationary, the unit root tests are conducted for each variable by using the augmented Dickey-Fuller (ADF) test, which was developed by Dickey and Fuller (1979). Table 2 summarizes the results of the ADF unit root tests, which indicate that the selected data series are integrated in order one, i.e., I (1). In other words, all data selected in this study are not stationary on level but stationary on first difference. To avoid spurious regression, the VEC model will be formulated on the basis of the first-difference data.

Apart from the unit root tests, the test for the cointegration relationship between variables is necessary for constructing the VEC model. The cointegration test was proposed by Johansen and Juselius (1990) and comprises five models: (1) Model 1 represents that all data series have a zero mean; (2) Model 2 represents that deterministic data have an intercept but no trend in the cointegration equations (CEs); (3) Model 3 suggests that data possess a linear trend and that there is an intercept but no trend in the CEs; (4) Model 4 suggests a linear trend in data and that both intercept and trend are in the CEs; and (5) Model 5 represents that data have quadratic trend and that there is an intercept but not trend in the CEs.

Hui and Yue (2006) argue that the practicability of Models 1 and 5 of the cointegration test of Johansen and Juselius (1990) has limited real-world application; therefore, this paper concentrates on Models 2, 3, and 4. There is an accepted assumption that long-run equilibrium demand probably has no trend (Wong et al. 2007). Thus, Model 3 is used in the cointegration test for this study. On the basis of a variety of statistics and criterion [e.g., sequential modified likelihood ratio test statistic (LR), final prediction error (FPE), Schwarz information criterion (SC), and Hannan-Quinn information criteria (HQ)], a four-lag length has been selected for the VEC model and the cointegration test. Table 3 reports the results of the cointegration test, in which one cointegration relationship has been found under the trace and max-eigenvalue tests, indicating that a long-run equilibrium relationship exists between the variables.

Table 3. Results of the Cointegration Tests

Parameter	Value
Variables	Q^{PPP}, P^c, GDP, R, U^e, PRO, CM^c, POP
Lagged difference	4
Results (trace test)	1
Results (max-eigenvalue test)	1

Dummy Variable Specification

A dummy has been inserted into Eq. (3) to capture the impact of global economic turbulence on PPP investment. It is acknowledged that a challenge of creating a dummy variable is to identify the length of the event window. According to Huang and Liu (2010), the announcements issued by RBA are useful for uncovering this issue within the Australian context because the central bank is sensitive to changes in both the domestic and global economic climates.

As mentioned previously, the dummy variable discussed in this paper is based on the year 2008, when the GFC began. The U.S. financial crisis sent shockwaves through the world in 2008. To hedge the rapid spread of the GFC, Australia's government launched an economic stimulus package in September 2008 (RBA 2008; Australian Treasury 2009), indicating that the GFC began affecting Australia in 2008Q3. As a result, the cash rates in Australia dropped dramatically from 7.25 to 3.0% between September 2008 and September 2009 (RBA 2013b). However, in October 2009, the RBA increased Australian cash rates by 25 basis points owing to the resuming growth of global and Australia's domestic economy (RBA 2009). This decision suggested that the impact of the GFC on Australia had faded in the fourth quarter of 2009. With this in mind, the values of 2008Q3, 2008Q4, 2009Q1, 2009Q2, and 2009Q3 can be established as 1 and 0 of others in the dummy time series.

VEC Model with a Dummy Variable

The VEC model with a dummy variable can be constructed after conducting the preceding tests. Table 4 indicates the estimates of the VEC model. Under the developed model, the Granger causality test can be run for the endogenous variables (Table 5 lists the test results). By applying Wald and joint F-tests, the null hypothesis that the independent variables (i.e., the proposed KPIs) do not significantly influence the Granger causality and dependent variable (infrastructure investment under PPPs) is rejected at the 0.90, 0.95, and 0.99 significance levels.

Table 5 indicates that all proposed KPIs involved as endogenous variables of the developed VEC model can affect the Granger causality of PPP infrastructure investment. Theoretically, the Granger causality is not a "real" causal relationship, but a "predictive causality." This means that the Granger causality test is designed to identify whether a time series (x) (independent variable) can be used to forecast another time series (y) (dependent variable). With this in mind, it can be concluded that the developed KPIs presented in Table 5 are significant for the evaluation of the macroeconomic environment in which a PPP project will be operating.

Apart from the KPIs in Table 5, the F-statistic of the coefficient of the dummy variable in relation to PPP infrastructure investment (Q^{PPP}) is not significant. However, the dummy coefficients associated with domestic economic conditions (GDP), R, U^e, PRO, and capital market conditions (CM^c) are significant at 0.90, 0.95, and 0.99 significance levels, respectively. This implies that the turbulence of the global economic climate is capable of substantially impacting the domestic economic system, money and capital markets, construction investment profitability, and purchasing power of population (unemployment level). In turn, all of these factors significantly affect a private sector entity's decision regarding

Table 4. Estimates of the VEC Model with a Dummy Variable

Variables	ΔQ_t^{PPP}	ΔP_t^c ΔGDP	ΔR_t ΔU_t^e	ΔPRO_t ΔCM_t^c ΔPOP_t
Q_{t-1}^{PPP}	1.00	—	—	—
P_{t-1}^c	−7.11 (−3.54)[a]	—	—	—
GDP_{t-1}	71.55 (10.95)[a]	—	—	—
R_{t-1}	−5.80 (−7.84)[a]	—	—	—
U_{t-1}^e	20.06 (10.15)[a]	—	—	—
PRO_{t-1}	−14.77 (−6.07)[a]	—	—	—
CM_{t-1}^c	5.07 (8.41)[a]	—	—	—
POP_{t-1}	5.91 (4.97)[a]	—	—	—
C	330.20	—	—	—
Eq. (1)	−0.94 (−3.45)[a]	—	—	—
Dummy	0.18 (0.50)	−0.04 (−0.45) −1.01 (−1.41)[b]	−1.16 (−2.64)[a] 1.04 (1.98)[b]	−1.03 (−2.34)[c] −2.23 (−3.04)[a] −1.05 (−0.89)
Error correction	$t-1$	$t-2$	$t-3$	$t-4$
ΔQ^{PPP}	0.64 (1.69)	0.14 (0.41)	0.03 (0.08)	0.11 (0.56)
ΔP^c	−40.28 (4.46)[a]	−8.03 (0.76)	−29.03 (−2.12)[a]	−44.08 (−3.82)[a]
ΔGDP	109.49 (5.71)[a]	75.75 (3.82)[a]	87.39 (4.41)[a]	32.39 (2.49)[c]
ΔR	−10.96 (−4.75)[a]	−6.50 (−3.52)[a]	−3.95 (−2.83)[a]	−2.77 (−2.75)[a]
ΔU^e	−15.96 (−2.75)[a]	−20.46 (3.97)[a]	−8.32 (−1.87)[b]	1.67 (0.54)
ΔPRO	0.23 (0.04)	8.14 (1.81)[b]	11.26 (2.27)[c]	5.46 (1.11)
ΔCM[c]	1.56 (0.86)	3.07 (1.92)[b]	1.32 (0.88)	−0.15 (−0.11)
ΔPOP	14.92 (1.15)	7.20 (0.77)	25.64 (2.57)[c]	25.75 (2.59)[c]
R-squared	0.84	—	—	—
Sum square residuals	0.05	—	—	—
Standard error equation	0.07	—	—	—
Log likelihood	120.56	—	—	—

[a]t-statistics significant at 0.99 significance level.
[b]t-statistic significant at 0.90 significance level.
[c]t-statistics significant at 0.95 significance level.

PPP infrastructure investment. In summary, GDP, interest rate, unemployment rate, manufacturing price, and stock price are the transmission mechanisms of the global economic disturbance to PPP markets. This empirical finding conforms with the study undertaken by Regan et al. (2011a). Thus, the KPI regarding global economy can also be considered critical to the PPP ex-ante evaluation.

To further investigate the contribution level of the developed KPIs to PPP investment, variance decomposition (VDC) has been adopted in this paper. Econometrically, VDCs are applied to interpret the amount of information about how each endogenous variable contributes to the forecasting of other variables in autoregression. It helps in understanding how much of the forecast error variance of each variable can be explained by the exogenous shocks to other variables. Specifically, if the shocks of the independent variables can significantly explain the forecast error variance of the endogenous variables, it can be concluded that the dependent variable is endogenous, and vice versa.

The results of the VDCs of Q^{PPP} are presented in Table 6 and also illustrated in Fig. 1, both of which indicate that the proposed KPIs explain 8–20% of the variability of PPP market. This finding indicates that the PPP investment is endogenous to the autoregressive system composed of the developed KPIs. The construction price, GDP, interest rate, and unemployment rate account for a substantial amount of the forecast error variances of PPP investment within a 12-quarter period, as listed in Table 6; 20.24, 18.39, 13.88, and 10.63%, respectively. This finding suggests that the construction price level, domestic economic conditions, money market conditions, and unemployment level are the most critical KPIs in PPP ex-ante evaluation, and they should be the highest priority of the PPP macroeconomic ex-ante evaluation conducted by the public sector.

Table 5. Results of the Granger Causality Tests

Dependent variable	Directions	Chi-square	P-values	Results
Q^{PPP}	$P^c \rightarrow Q^{PPP}$	32.12	0.00[a]	Y
	$GDP \rightarrow Q^{PPP}$	35.32	0.00[a]	Y
	$R \rightarrow Q^{PPP}$	23.45	0.00[a]	Y
	$U^e \rightarrow Q^{PPP}$	17.88	0.00[a]	Y
	$PRO \rightarrow Q^{PPP}$	8.66	0.07[b]	Y
	$CM^c \rightarrow Q^{PPP}$	10.20	0.04[c]	Y
	$POP \rightarrow Q^{PPP}$	12.65	0.01[a]	Y

Note: Y indicates the existence of Granger causality.
[a]Rejection of null hypothesis at the 0.99 significance level.
[b]Rejection of null hypothesis at the 0.90 significance level.
[c]Rejection of null hypothesis at the 0.95 significance level.

Table 6. Variance Decomposition Results of Q^{PPP}

Period	Q^{PPP}	P^c	GDP	R	U^e	PRO	CM^c	POP
1	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	63.19	4.12	14.36	0.06	1.73	13.14	1.70	1.71
3	43.18	13.99	13.19	4.67	8.15	9.50	5.60	1.71
4	36.67	12.50	13.02	8.10	9.09	8.13	7.54	4.94
5	32.24	17.53	12.40	7.06	8.42	7.21	10.04	5.09
6	26.03	14.84	**18.39**	11.55	8.70	7.30	8.82	4.36
7	23.31	16.53	17.29	**13.88**	9.83	7.60	7.80	3.76
8	21.50	17.48	16.26	13.82	10.24	7.01	8.80	4.88
9	21.09	17.24	15.84	13.48	**10.63**	6.83	9.29	5.60
10	20.64	17.54	16.16	13.17	10.49	7.34	9.11	6.53
11	20.18	18.22	15.94	13.20	10.22	7.56	8.86	7.82
12	20.01	**20.24**	15.57	12.81	10.14	7.74	8.69	7.80

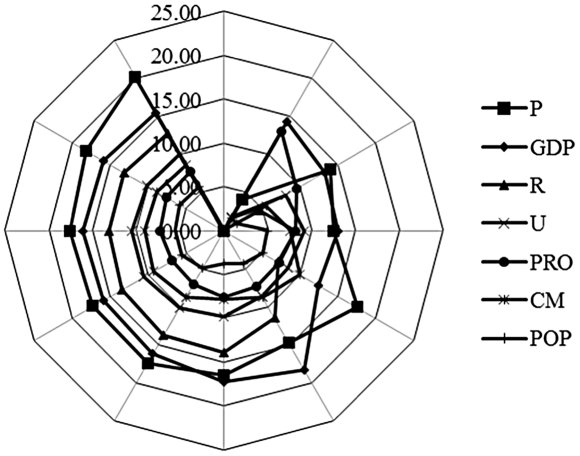

Fig. 1. Variance decomposition results of Q^{PPP}

Conclusions

This paper has conceptually developed a set of KPIs for the ex-ante evaluation of macroeconomic environment within the context of PPP infrastructure projects. The proposed KPIs have been empirically validated by a VEC model with a dummy variable. According to the results of the Granger causality tests, first, the KPIs developed as the endogenous variables of the VEC model can affect the Granger causality of PPP infrastructure investment. This means that such KPIs are critical to the ex-ante evaluation of PPPs. Second, the estimates of the VEC model suggest that the coefficient of the dummy variable in relation to PPP investment is not significant, but it is significant to five other endogenous variables (e.g., GDP, interest rate, unemployment rate, manufacturing price–profitability, and stock price) at 0.90, 0.95, and 0.99 significance levels. This finding indicates that there is an indirect significant relationship between the PPP market and the global economic climate, and that the fluctuations of global economic system are capable of influencing PPP investment through these variables. Thus, it is proven that the condition of the global economy is an essential KPI for PPP ex-ante evaluations. Finally, by using variance decomposition, this paper has identified that the developed KPIs can significantly explain 8–20% of the variability of the PPP market. In addition, the construction price level, domestic economic conditions, money market conditions, and unemployment level are the most critical KPIs in the ex-ante evaluations of PPP infrastructure projects.

Previous empirical evidence has suggested that domestic and global economic climate, total purchasing power of population (unemployment level), and conditions of construction, money, and capital markets play vital roles in PPP ex-ante macroeconomic evaluations. This key finding is consistent with the common knowledge that the success of a PPP project heavily depends on the performance of national and industrial economic climate and a sound finance structure. Accordingly, the KPIs derived in this paper are practical and able to provide public sector with assistance in conducting a comprehensive and effective ex-ante evaluation for the entire macroeconomic environment in which a PPP infrastructure project will be implemented.

Macroeconomic environments are dynamic; thus, governments should seriously consider whether PPP is a suitable method for procuring an infrastructure asset when the macroenvironment is not favorable. However, macroeconomic assessment is not the entirety of a PPP ex-ante evaluation, but only a significant part of it. Determining what type of procurement should be applied is a complex process; therefore, it is difficult and irrational to make a judgement on the use of PPPs depending only on a macroeconomic assessment. Decision makers in the public sectors that will embark on infrastructure development need to examine all vital issues under an effective framework to identify which procurement and type of contract are the most appropriate choices for the projects. Nevertheless, the aim of this paper is simply to derive useful KPIs, rather than develop a decision-making framework and examine the nature of the contract. As a result, the discussion about using PPPs within the context of unfavorable environment has not been presented. This is a research limitation; the selection of a suitable approach between PPPs and other traditional procurements is a promising topic for future study.

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