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Model for predicting the Success of Public-Private Partnership Infrastructure Projects in Developing Countries: A Case of Ghana

Abstract

This paper develops a practical tool for predicting Public-Private Partnership (PPP) project success in developing countries using Ghana as example. The predictive model examines the causal relationship between CSFs and success criteria for PPP projects. First a conceptual model for PPP projects success was proposed. Second, the theoretical model was tested by means of a questionnaire survey with experienced PPP experts. Using the regression analysis technique, a predictive model for PPP project success was developed. The regression model shows three best predictors of PPP project success in Ghana, these include; appropriate risk allocation and sharing, sound economic policy and right project identification. Various statistical tests including ANOVA, tolerance and variance inflation factor (VIF)), homoscedasticity and Durbin Watson tests confirmed the validity and goodness of fit for the model. The substantive model will enable PPP practitioners including designers, public clients and engineers in Ghana and other neighbouring developing countries particularly sub-Saharan Africa to predict the likely success of their PPP projects prior to their implementations.

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Keywords: Public-Private Partnerships, projects success, critical success factors, success criteria, regression analysis, Ghana.

Introduction

Public-Private Partnership (PPP) is defined as an arrangement between the public and private sectors, in which both parties bring together their complimentary skills and assume different levels of responsibilities and risks for the sake of providing efficient public infrastructure and services (Efficiency Unit, 2003; Akintoye et al. 2003). Considering the rapid increase in demand for public infrastructure and services, the adoption of the PPP policy by many governments in developing countries has risen significantly over the last couple of decades (Dulaimi et al. 2010; Ke et al. 2010; Chou and Pramudawardhani 2015). Generally, PPP is considered to offer great financial relief to governments (Ismail and Azzahra 2014). In addition, it offers governments, particularly in developing countries the opportunity to develop sustainable and modernized public infrastructure compared to the conventional procurement approach (Chan et al. 2009). Despite the substantial positives reported about the PPP concept, there are some potential disadvantages associated with it. Essentially, PPP projects have very long procurement periods and are very costly to procure compared to the traditional bid-build method (Grimsey, 2003). In fact, the procurement procedure for PPPs can go beyond 24 months. Further, PPPs have very high cost of financing and complex contractual arrangements.

In 2013, PPP investments in developing countries reached a total amount of US$ 150.3 billion, with Brazil and India contributing largely to the total investments (World Bank, 2013). Unfortunately, not all developing countries have benefited fully from the PPP concept particularly for countries in the South Asia, Sub-Saharan Africa, Middle East and North Africa regions (World Bank 2015). Many PPP projects initiated in some developing countries particularly Ghana have

either failed or are distressed (Kumaraswamy and Zhang 2001; Tam 1999; Kayaga, 2008; World Bank 2015). In this regard, it is very crucial for practitioners in Ghana and other developing countries to considerably and continuously be informed of the likely success of PPP projects prior to their implementations. This is of significant value because based on the predicted project success; practitioners can confidently decide whether the proposed project is suitable through PPP scheme (Ling et al. 2004). In addition, practitioners would be adequately informed of the management strategies and measures to adopt in order to achieve the desired success level of their PPP projects (Elattar 2009).

In the last couple of decades, a considerable number of research studies have identified and discussed the critical success factors (CSFs) for PPP projects in developing countries (e.g. see Chan et al. 2010a; Babatunde et al. 2012; Meng et al. 2011; Ismail 2013; Askar and Gab-Allah 2002; Jamali 2004; Abdul-Aziz and Kassim 2011). Though the research outputs of previous studies expand practitioners' understanding on how to successfully procure PPP projects in Ghana and developing countries in general, little attempt has been done to examine the causal relationship between the CSFs and success criteria for PPP projects. Previous studies only nominated and ranked CSFs or success criteria for PPP projects based on case studies or opinion surveys (Babatunde et al. 2012; Osei-Kyei and Chan 2015; Li et al. 2005; Abdel Aziz, 2007) with no additional effort to construct a pragmatic model that links CSFs and success criteria for PPP projects in developing countries particularly for Ghana.

As part of a larger research project which aims to develop a best practice framework for PPP implementation in a developing country (i.e. Ghana); this paper develops a mathematical model that predicts PPP project success in developing countries given a set of CSFs and success criteria. It is believed that the substantive model will aid both public and private sectors to assess the likely

success of PPP projects prior to their implementations and further inform them on the key attributes which need to be controlled and carefully managed in order to achieve the desired success level.

Review of CSFs and Success criteria for PPP projects

As emphasised by Rockart (1982), CSFs are the "few key areas of activities where favourable results are absolutely necessary for a manager to achieve his/her goal". Apparently, CSFs is one of the topical research areas in PPP (Ke et al. 2009). It has been explored from different countries' and sectors' perspectives. For example, Babatunde et al. (2012) found out that political support, favourable legal framework, stable macroeconomic condition and competitive procurement are some of the key requirements for PPP project implementation success in Nigeria. Also, Meng et al. (2011) mentioned that competition, reliable service delivery, employment of professional advisors, open and constant communication and detailed project planning are some essentials needed for PPP water projects in China. Furthermore, Ismail (2013) found out that some key CSFs for the Malaysian PPP market include good governance, commitment and responsibility of parties, favourable legal framework, sound economic policy and available financial market.

Also, in China, Chan et al (2010) indicated that for PPP projects to be successful, some key measures including political support, transparent procurement, stable macroeconomic conditions, clarity of roles and responsibilities, competitive procurement and public support should be carefully observed. Li et al. (2005) from the U.K.'s perspective pointed out that strong private consortium, available financial market, appropriate risk allocation and good feasibility studies are required to ensure the successful implementation of PPP/PFI projects. Lastly, Jefferies (2006) from

the Australian perspective found out that some of the critical factors required for PPP projects to be successful include streamline of approval process, clear project brief and client outcomes, competition, trust and teamwork. From the above pieces of literature, it is realised that different authors have identified different set of CSFs for PPP projects. Although there are some similarities in the outcomes of past studies, essentially, the similarities are mostly observed in studies conducted in either developing or developed countries (Osei-Kyei and Chan, 2017).

CSFs and Success criteria are often used interchangeably in the literature; however, these two terminologies are distinct (Lim and Mohamed, 1999; Osei-Kyei et al. 2017). While CSFs look at how success can be achieved, success criteria rather focus on the parameters on which a project can be deemed or judged as successful (Chan et al. 2002). Therefore, success criteria simply denote the outcomes of a successful project (Lim and Mohamed, 1999). Indeed, like CSFs, success criteria have been explored extensively in the literature particularly for traditional bid-build projects (Al-Tmeemy et al. 2011). Success measures of traditional bid-build projects have over the last couple of decades move from the conventional measures usually termed as the "iron triangle" (i.e. cost, time and quality) to the inclusion of more subjective criteria such as safety, reduction in disputes, technology transfer, functionality, occupational health and safety, litigations, environmental performance, material management, sponsors satisfaction and long term partnership (Chan and Chan, 2004; Nguyen et al. 2004; Toor and Ogunlana, 2008; Lai and Lam, 2010; Ahadzie et al. 2008; Idrus et al. 2011).

Certainly, considering the unique characteristics of PPP projects including complex contractual and stakeholder management, long-term arrangement and risk sharing, their success measures will differ from the measures of the traditionally procured projects. For instance, Mladenovic et al. (2013) highlighted that some success measures for PPP projects can include profitability,

efficiency, level of services and effectiveness. Further, Liu et al. (2015) indicated that stakeholder satisfaction, strategies, processes, capabilities and stakeholder contribution can be used to assess the performance of PPP projects. Lastly, Dixon et al. (2005) highlighted that the success of PPP projects can be assessed using measures such as efficient and cost-effective procurement process, time, feedback from users and adherence to specifications.

Conceptual model for PPP projects success

A theoretical model for PPP projects success is developed using the outputs of Osei-Kyei and Chan (2015) (see Table 1) and Osei-Kyei et al. (2017) (see Table 2). Specifically, the checklist of CSFs and success criteria for PPP projects developed through a systematic review of literature by Osei-Kyei and Chan (2015) and Osei-Kyei et al. (2017) were adopted. Figure 1 shows the conceptual model for PPP projects success.

The conceptual model is grounded on the theoretical assumption proposed by Lim and Mohamed (1999) on project success framework. Lim and Mohamed indicated that a project success model is composed of two key parts; factors and criteria. Factors denote the circumstances or conditions required to achieve project success. Whereas criteria indicate a set of principles by which success is judged. This implies that the factors and criteria are CSFs and success criteria of a project respectively.

[Please Insert Figure 1 here]

Against this background, the conceptual model consists of two major components; CSFs (i.e. first component) and success criteria (i.e. second component) for PPP projects. In the theoretical model, the CSFs for PPP projects are grouped into six broad categories. The groupings are done drawing on assertions by Li (2003) and Abdel Aziz (2007). The writers indicated that the

conditions which influence PPP projects success are its environment (program level) and internal organisation (project level). Therefore, a six-factor grouping of CSFs for PPPs was deemed suitable to represent both its environment and internal organisation. The six categories include: Political, Economic, Technological, Social, Organizational and Managerial conditions (PETSOM). In essence, each condition of success has a relationship with the other. For instance, the political category has a direct influence on both the economic and organisational conditions of PPP projects success and vice versa. The second component of the model (i.e. success criteria) comprises of 15 criteria, which are derived based on the satisfaction of the main stakeholders of PPP projects (i.e. public, private and users) (refer to Osei-Kyei et al. 2017).

In general, as demonstrated in the model (Fig. 1), the six conditions collectively influence the achievement of the success criteria, which then determines the success of PPP projects.

Research Methodology

Pre-testing

A structured questionnaire was designed for an empirical survey. Before the survey, the questionnaire was piloted with four local PPP experts with extensive research and/or industrial experience in PPP project implementation in Ghana. The basic reason for the pre-testing was to ascertain the clarity and applicability of the sets of factors (i.e. CSFs and success criteria) within the Ghanaian context and developing countries in general. The experts confirmed the adequacy of the list of success criteria and suggested few modifications in the clarity of some CSFs.

Questionnaire survey

An empirical questionnaire survey was conducted with experienced PPP practitioners in Ghana. Importantly, a questionnaire survey was adopted because it allows respondents to have more time to ponder over their responses without any interference from the researcher; this therefore eliminates bias and yields a more objective outcome. Moreover, this study aimed to develop a mathematical predictive model and that certainly requires detail statistical analysis. Therefore, a questionnaire survey was undoubtedly the best option to enable the researchers achieve the objective of the paper. The questionnaire requested respondents to rate the importance of each success criterion and CSF for PPP projects on a five–point Likert rating item (i.e. 1- least important to 5- extremely important) (Osei-Kyei and Chan 2017a; 2017b). Respondents were selected based on their direct practical and/or research experience in PPP projects in Ghana.

In total, 120 potential practitioners from the academic and industrial sectors were sourced and identified from dedicated private organizations, state agencies that have expressed strong interests in PPP projects (including Public Investment Division, Ghana Highways Authority, Department of Urban Roads, Ministries departments, Local government departments, Ghana Water Company Limited and Public Procurement Authority) and publications on PPP focused on Ghana in peer-reviewed academic journals, conferences and books. Questionnaires were sent to targeted respondents either by emails or face-to-face (for majority of questionnaires). Overall, 77 questionnaires were received, which represents a response rate of 64.17%. Comparatively both the sample size and response rate are bigger than some previous related studies conducted in developing countries (e.g. see Chan et al. 2010a (53 responses); Babatunde et al. 2012 (49 responses); Ke et al. 2011 (46 responses); Wibowo and Alfen, 2014 (30 responses)) (Osei-Kyei and Chan 2017b). Nonetheless, the extensive practical and/or research experience (i.e. 61% have between six to 20 years of PPP experience) shows the genuineness and reliability of the survey

responses (Table 3). Further, from Table 3, 80% of respondents are practitioners who are mostly exposed to the intricacies of PPP projects compared to academics. This also reassures the authenticity of the survey data for analysis (Osei-Kyei and Chan 2017b).

[Please Insert Table 3 here]

Analytical techniques

The Statistical Package for Social Sciences (SPSS) 21.0 was used as a tool to perform multiple regression analysis on the survey responses.

Multiple Regression Analysis

Multiple regression analysis technique was used in this study to construct a mathematical model, which predicts the success of PPP projects in developing countries based on data from Ghana. Specifically, the multivariate analysis technique was used to define the nature and character of the connections between variables (i.e. CSFs (independent variable) and success criteria (dependent variable)) (Cserhati and Szabo 2014). This implies that by performing multiple regression analysis, the significant predictors (CSFs) of PPP projects success in developing countries are identified (Chan et al. 2004). Equation of multiple regression analysis is given as (Cohen et al. 2013):

$$Y_p = \alpha + \beta_1 X_i + \beta_2 X_{ii} + \ldots + \beta_k X_k + \varepsilon_i \qquad \text{(Eq. 1)}$$

Where α is the intercept/ constant, β_1, β_2, … , β_k are the regression coefficients which denote the estimate change in Y_p for a unit change of $X_i, X_{ii} \ldots, X_k$, ε_i represents the predictive error or residual, Y_p is the dependent variable and X_i, X_{ii}, … , X_k are the predictors.

In performing multiple regression analysis, the basic assumptions of linearity, independence, multicollinearity, homoscedasticity and normality are required to be tested and satisfied in order to ascertain the adequacy and fitness of the predictive model. These underlying assumptions can be examined by plotting the standardized deleted residual against standardized predicted values (i.e. homoscedasticity, linearity and independence) and normal probability plot (i.e. normality). Further, the Durbin-Watson test is performed to check for serial correlation between errors, likewise diagnostic tests including tolerance and variance inflation factor (VIF)) are conducted to measure the correlation among the predictor variables (i.e. multicollinearity).

Validation of the Regression model

Validation is a very essential step in model development to ascertain the substantive model's generalizability and reliability. Model validation actually ensures that the substantive model is not only applicable to the sample data used in the model development but it has the predictive power for different sample data from the same population. In this study, the regression model was cross validated using Stein's equation (Ahadzie et al. 2008). Steins equation recalculates the adjusted R^2, which indicates how well the equation model predicts values of a different data set from the same population (Field, 2013). According to Field, the adjusted R^2 computed from SPSS uses Wherry's equation. However, Wherry's equation is considered to be flawed because it does not indicate how well the regression model predicts scores of a different data set from the same population. Thus, Field suggested that Stein's equation should be used to cross – validate

regression models by recalculating the adjusted R^2. Stein's formula for cross validation is given as follows (Stevens 2012):

$$\text{Adjusted } R^2 = 1 - \left[\left(\frac{n-1}{n-k-1}\right)\left(\frac{n-2}{n-k-2}\right)\left(\frac{n+1}{n}\right)\right]\left(1-R^2\right) \qquad \text{(Eq. 2)}$$

Where, R^2 is the unadjusted value, k is the number of regressor variables in the model and n is the number of cases/sample.

Data Analysis and Results

Project Success Index (PSI) for PPP projects (dependent variable)

Table 4 shows the mean scores of the set of 15 success criteria for PPP projects in Ghana (Osei-Kyei and Chan 2017b). However, using factor analysis technique, Osei-Kyei and Chan (2017b) grouped the fifteen success criteria into three major components (i.e. critical success criteria groupings). The fuzzy synthetic evaluation (FSE) technique was then used as the main tool to formulate an equation for determining the PSI of PPP projects in developing countries using Ghana as an example. The three major groupings of the 15 success criteria are local development and disputes reduction, profit, cost and technical specifications. Details of the discussion on the three clusters are found in Osei-Kyei and Chan (2017b). The Project Success Index model (success outcome) developed using the FSE is given as follows:

PSI for PPP projects in developing countries = (0.301 x local development and disputes reduction) + (0.347 x profit) + (0.352 x cost and technical specifications) (Eq. 3)

In this paper, the PSI for PPP projects functioned as the dependent variable for the regression analysis. The factor score of each critical success criteria grouping was substituted in the PSI

equation (Eq. 3) and with the aid of SPSS, the dependent variable for the regression analysis was computed.

The dependent variable is expressed as follows:

PSI = (0.301 x LD_DR) + (0.347 x PFT) + (0.352 x CT_TS)

Where, LD_DR = Local development and disputes reduction Factor Score, PFT = Profit Factor Score and CT_TS = Cost and Technical specifications Factor Score.

[Please Insert Table 4 here]

Model Development

Given the small sample size and large number of regressor variables (i.e. CSFs), it was important to reduce the number of independent variables in order to minimize the impact of weak predictive model (Doloi 2012). Pearson correlation analysis was performed to screen out the independent variables that do not correlate significantly with the outcome variable (i.e. PSI for PPP projects). In this regard, correlation significant values greater than 0.05 (2-tailed) were considered insignificant and vice versa. It is worth noting that this initial screening process is comparable to the removal of statistical outliers in multivariate regression analysis and it also satisfies the assumption of linearity (Ling et al. 2004). Table 5 shows the results of the Pearson correlation analysis between the independent variables (CSFs) and the dependent variable (PSI).

[Please Insert Table 5 here]

As shown in the table, ten independent variables have their significance values greater than 0.05, therefore they will be eliminated in the next stage of analysis. These variables include political stability (p–value = 0.175), existence of PPP project champion (p-value= 0.585), government

providing financial support (p-value= 0.918), public/community participation and coordination (p-value= 0.272), public/community support (p-value= 0.133), choosing the right private consortium (p-value= 0.200), streamline of approval process (p-value= 0.192), long term demand for project (p-value= 0.222), clear goals and mutual benefits objectives (p-value= 0.229), and clarity of roles and responsibilities (p-value= 0.075).

Stepwise selection procedure was used to construct the regression model. It is a robust tool which produces the most parsimonious model by choosing the best subsets in the sample data that best predict the criterion variable (Brace et al. 2003; Chan and Kumuraswamy 1999). It is the most sophisticated selection procedure when a large number of predictors are involved in the regression analysis (Ahadzie et al. 2008). Thus, considering that the number of predictors (CSFs) in this study is quite large, it was logical and appropriate to employ the stepwise selection procedure in the regression analysis. The stepwise regression results indicate that three independent variables produced the optimum model (Table 6). The three significant factors account for 42.8% of variance in the dependent variable. The regression equation is significant, with a p value of 0.000 (Table 7). Also, the coefficients of the three predictors are significant (i.e. p value ≤ 0.05) (Table 8). Using the coefficients given in Table 7, the regression equation is expressed as follows:

$$Y_{\text{(Success of PPP projects)}} = -2.705 + 0.353 \text{ (appropriate risk allocation and sharing)} + 0.312 \text{ (sound economic policies)} + 0.307 \text{ (right project identification)} \quad \text{Eq. (4)}$$

[Please Insert Table 6 here]

The goodness of fit for the model is determined by the coefficient of determination (i.e. R^2) (Molenaar and Songer, 1998). Specifically, R^2 measures the strength of correlation among variables and indicates the proportion of variance in the criterion variable (Ling et al. 2004;

Ahadzie et al. 2008). Further, R^2 reflects the predictive power of the substantive model (Ling et al. 2004). However, it is worth noting that R^2 does not give a better estimate of the model's goodness of fit but rather it is the calculated adjusted R^2. This is because R^2 rapidly increases when new independent variables are introduced in the model (Doloi 2012); hence, it overestimates the success of the model in real world situation (Ahadzie et al. 2008). Therefore, when measuring the predictive power of a regression model, the adjusted R^2 is rather referred (Doloi 2012). As shown in Table 6, the adjusted R^2 for the regression model is 42.8%. This is reasonably within an acceptable range when compared with past related studies that used multiple regression analysis (eg. see Doloi 2012 (adjusted R^2 = 35.4%, 38.7% and 35.3% for three models); Xiao and Proverbs 2003 (adjusted R^2 = 45.8%); Molenaar and Songer 1998 (adjusted R^2 from 0.28 to 0.47 for five models); Konchar and Sanvido, 1998 (51%)). Notwithstanding according to Fields (2013), the difference between the adjusted R^2 and R^2 (i.e. shrinkage) should be less than 0.50 for a valid predictive model and goodness of fit for the model. Here, the shrinkage is 0.02 which is far below the acceptable limit of 0.5. Therefore, the model is valid and generally robust to predict the success of PPP projects in Ghana and other developing countries (Oyedele, 2013)

[Please Insert Table 7 here]

[Please Insert Table 8 here]

To further ascertain the goodness of fit and adherence to the basic assumptions of regression analysis, regression diagnostics (i.e. residual analysis) including Durbin-Watson test, multicollinearity, normality and homoscedasticity were undertaken. The Durbin- Watson test measures the serial correlation between residual errors (Field 2013). The test statistics vary

between 0 and 4, where a value close or equal to 2 indicates that the residual errors are uncorrelated (i.e. independent), hence the goodness of fit of the substantive model (Oyedele 2013). As shown in Table 6, a test statistic value of 1.829 is obtained for the model, which is close to 2. This signifies that the errors are not correlated; therefore the assumption of independence is satisfied (Ahadzie et al. 2008).

Multicollinearity measures the relationship between predictor variables (Field 2013). It is determined based on the values obtained for tolerance statistic and variance inflation factor (VIF). Ideally, there should be no multicollinearity between predictor variables because it becomes difficult to assess the individual importance of a predictor, if predictors are highly correlated (Ling et al. 2004). The tolerance statistic is the reciprocal of VIF and it ranges from 0 to 1, where a value close to 0 signifies strong relationship among the predictor variables and vice versa (Oyedele 2013). Similarly, VIF ranges between 1 and 10, where it is recommended that VIF should be one. However a value less than 5 should suffice and VIF of 10 is a cause for concern (Field, 2013). The results presented in Table 8 shows that multicollinearity is not a problem for this model because the tolerance values range from 0.866 to 0.942, whereas the VIF for all predictors are less than five (Hair et al. 2006). This shows that the predictor variables are not highly correlated and reaffirms the goodness of fit of the regression equation.

Assumptions of normality and homoscedasticity are determined based on the histogram of standardized residuals (Fig. 2), normal probability plot (Fig. 3) and scatter plot diagram (Fig. 4). As presented in Fig. 2, the bell shaped and symmetrical histogram of standardized residuals indicate that the residual errors are normally distributed, thus the assumption of normality is satisfied.

[Please Insert Figure 2 here]

Further, the normal probability plot shows data points clustered to the diagonal line (Fig. 3); this reaffirms the normal distribution of the residual errors (Xiao and Proverbs, 2003). The random pattern of the data points in the scatter plot (Fig. 4) shows that the variance of the residual errors is constant; in essence, 95% of the data points fall within +2 and -2 intervals (Ahadzie et al. 2008). Thus, the assumption of the homogeneity of variance (i.e. homoscedasticity) is satisfied (Xiao and Proverbs 2003). In general, the regression diagnostics clearly indicate that there is no bias and the model is valid and adequate (Field, 2013).

[Please Insert Figure 3 here]

[Please Insert Figure 4 here]

Validation of the model

As previously mentioned, validation forms a key step in developing a substantive predictive model. In this study, the Stein's equation was used for cross validation by recalculating the adjusted R^2 (Field 2013). The adjusted R^2 using Stein's formula (Eq. 2) is calculated as follows:

$$\text{Adjusted } R^2 = 1 - \left[\left(\frac{77-1}{77-3-1}\right)\left(\frac{77-2}{77-3-2}\right)\left(\frac{77+1}{77}\right)\right](1-0.450) = 0.4005$$

Stein's equation produced an adjusted R^2 of 40.1%, which is quite close to the observed adjusted R^2 (i.e. 42.8%). Moreover, the difference between the computed adjusted R^2 using Stein's formula and the observed R^2 (i.e. 0.450 – 0.401) is 0.049, which is less than 0.50. These therefore means

that the cross validity of the substantive model is very good and the regression equation has the potential to predict quite well on different data samples from the same population.

Application of the regression model

Example of how the substantive model could be used in real world situation is shown in this section. For any given PPP project, a group of experts or project participants from both public and private sectors at the early stages will rate on a five-point scale, how the three variables in Eq. 4 are likely to be achieved in the given project (i.e. 1= is not likely to be achieved, 3 = average and 5= likely to be achieved very well).

Assuming, each predictor variable is likely to be achieved very well and it is rated five by all respondents in a given project. The mean value for each CSF will therefore be 5.0. Substituting the mean value of each CSF, the predicted success for the given project is calculated as follows:

$$Y = -2.705 + (0.353 \times 5) + (0.312 \times 5) + (0.307 \times 5) = 2.155$$

This means that the highest predicted score for a given project's success is 2.155. Also, the threshold score is calculated as follows; supposing that a mean value of 3.0 (i.e. average) is obtained for each predictor:

$$Y = -2.705 + (0.353 \times 3) + (0.312 \times 3) + (0.307 \times 3) = 0.211$$

The implications of the results are that practitioners in developing countries should be cautious of PPP projects with predicted success below 0.211. However, projects with predicted success within the range of 0.211 and 2.155 are not a cause for concern and they are likely to be implemented successfully.

Discussion of results

The regression analysis has made it possible to develop a practical predictive model for PPP projects success in Ghana and developing countries in general drawing on the conceptual model presented in Fig. 1. The regression model comprehensively and practically links the CSFs and success criteria for PPP projects based on empirical data. As presented in the regression equation (Eq. 4), three CSFs emerged as significant in predicting PPP projects success in developing countries. These include appropriate risk allocation and sharing, sound economic policies and right project identification. Generally, the regression results are consistent with the findings of previous studies including Osei-Kyei and Chan (2015), where these three CSFs were part of the most reported CSFs in literature.

Appropriate risk allocation and sharing

Appropriate risk allocation and sharing is the most significant predictor in the substantive predictive model. Previous studies including Chan et al (2010a), Babatunde et al (2012) and Meng et al (2011) also stressed out the significance of proper risk allocation and sharing in the implementation of PPP projects in developing countries. It is worth noting that appropriate risk allocation and sharing is not only critical in developing countries but developed countries as well. This is because previous studies conducted in the advanced countries including Li et al (2005), Cheung et al (2012), Jefferies et al (2002) and Dixon et al (2005) also identified this CSF as very essential. Notwithstanding, Osei-Kyei and Chan (2015) in a review of CSFs literature found that appropriate risk allocation is critical to PPP success irrespective of jurisdiction. Basically, risk sharing among parties forms a key component of PPP project management (Cheung and Chan, 2011). In PPPs, risks are to be properly identified and allocated to the party with better mitigation measures (Ameyaw and Chan, 2015; Xu et al. 2010).

In recent times, quite a number of PPP projects in developing countries particularly Ghana and other African countries have failed to meet their objectives due to the misallocation of risks. Is either the government retains excessive risks or fails to completely transfer risks to the private party (Ho, 2006; Ameyaw and Chan, 2013). As seen in the Lekki toll road concession project developed in Nigeria the demand/revenue risk was allocated to the concessionaire. After a period of public and political agitations over high toll fees, the government decided to absorb the risk. However, the government upon realising that it cannot properly deal with the risk quickly transferred it back to the concessionaire. Certainly, the back and forth transfer of risks have not contributed to the successful performance of the project. In addition, Ghana's first large-scale housing PPP project completely failed due to the excessive risks retained by the government. The risks included the demand and revenue, political, social and financial risks of the project. In PPPs, if risks are wrongly allocated or excessively retained, the parties responsible for managing will not have the capacity to adopt proper mitigation measures, and this will definitely lead to the downfall of the project (Chan et al. 2010b). It is therefore important for practitioners in developing countries to be cautious of the allocation of risks when implementing PPP projects. Essentially, some PPP projects success indicators of appropriate risk allocation and sharing in developing countries include effective risk management, profitability, disputes and litigations reduction, and adherence to time and cost (Osei-Kyei and Chan, 2017b).

Sound economic policy

Sound economic policy is the second most significant predictor in the regression equation. It has a coefficient of 0.312. Chan et al (2010a) and Ismail (2013) also identified sound economic policy as important in China and Malaysia respectively. As a matter of fact, this predictor may not be very significant in other developed countries because they have the existing enabling economic

environment and policy towards private sector investments and development compared to the emerging economies. Moreover, Li et al (2005) identified this significant predictor of PPP projects success as moderately important in achieving PFI/PPP success in the U.K. Economic policies have a direct influence on the state of a country's macro-economic condition. In essence, good economic policies positively affect a country's economic variables including inflation rates, interest rates and consumer price indices (Coeure and Jacquet, 2010). Moreover, they provide good credibility of price regimen and the convertibility of currency (Li et al. 2005). It is worth noting that good economic policies do not always enhance the stability of macro –economic condition but also promotes private sector development (Chan et al. 2010a). Examples of such good economic policies include joint venture funding programmes, government guarantees, tax holidays and rebates on imported equipment.

In Ghana and other developing countries, most governments have begun introducing some good economic policies towards PPP arrangements. A notable example is the Viability Gap Fund (VGF) and Project Development Fund (PDF) introduced by the Indian and South African governments respectively (ADB, 2011; USAID, 2005). The prime objective of this good initiative is to make PPP projects bankable and financially attractive to investors particularly foreign investors in both countries. Similarly, the Ghanaian government has set up various funds including Ghana Infrastructure Investment Fund (GIIF), Project Development Facility (PDF) and Viability Gap Scheme. These funds enable public authorities undertake pre-feasibility and full feasibility studies for their proposed PPP projects. In addition, the funds intend to make PPP projects financially attractive to private investors (MOFEP, 2011). Other governments in developing countries rather provide guarantees and joint venture funding as forms of good economic policies towards PPP projects. Taking the N4 toll road project developed in both South Africa and Mozambique, for

example, the South African and Mozambique governments provided debt guarantee, which enable the investor to raise the required amount from local financial institutions.

Obviously, considering the unattractive macro-economic condition in developing countries, sound economic initiatives like the ones introduced by some governments are very vital towards PPP development. But it is also crucial for governments in developing countries to ensure the sustainability of the economic policies and initiatives they introduce, particularly for funding programmes towards PPP investments. Profitability, local economic development and adherence to cost are some important success features of sound economic policy in PPP projects in developing countries.

Right project identification

This predictor has a coefficient of 0.307 and it is the last significant predictor variable in the regression equation. Essentially, Askar and Gab-Allah (2002) identified this predictor variable as very important in achieving PPP projects success in Egypt. Right project identification means that the project procured through PPP scheme is suitable and it has a strong technical and economic rationale (PPIAF, 2009). Tiong et al (1992) gave two general ways of selecting the right project for PPPs. First, there has to be a demonstrated and accepted need for the project/facility by the public. Second, there should be a near-monopoly in providing the public facility.

In developing countries including Ghana, selecting the right project could be problematic and daunting. The reason is that majority of the public facilities provided are politically motivated; they are not procured primarily from a national infrastructure plan but on the basis of 'campaign promises'. A good and well-established national infrastructure plan would considerably enable public authorities to select the right project but such plans are not available in most developing

countries compared to the advanced countries. It is therefore crucial for governments in developing countries to engage all stakeholders, so that a single common infrastructure plan could be devised and strictly enforced irrespective of the political party in administration.

Notwithstanding, PPIAF (2009) has presented three broad factors, which public authorities in developing countries should consider when selecting projects for PPP schemes. The factors include project objectives, practicality and value for money. Specifically, project objectives cover issues such as the economic value of the facility, risks associated with the facility and environmental issues. Practicality relates to the political, legal and social issues of the facility whereas, value for money covers issues of financial sustainability of the facility.

Right project identification relates to several success indicators of PPP projects in developing countries. These include local economic development, profitability and satisfying the need for public facility/service.

Implications and Recommendations for practitioners (including consortia and public sector organizations)

~~Considering the pioneering nature of this study, where CSFs and success criteria for PPPs in developing countries are linked using empirical data;~~ The outputs of this research study are substantially impactful towards implementing successful PPP projects in developing countries particularly Ghana. Essentially, they offer useful practical implications to consortia (i.e. financiers, architects, engineers and project managers) and public sector organizations (i.e. client) interested in PPP projects in Ghana. First, the regression equation derived will considerable assist practitioners (both clients and consortia) to reliably predict the likely success of PPP projects prior to their implementations. Second, practitioners would be informed of the management measures

and techniques that need to be adopted in order to achieve the desired success level for their projects. Lastly, the pragmatic model will guide practitioners on the few important areas where resources should be channelled in order to enhance the general performance of PPP projects. However, it is worth noting that though the regression results reveals three significant predictors of PPP projects success in developing countries, the other independent variables should not be disregarded when implementing successful PPP projects. But much attention should be given to the three significant predictors in the model.

Limitations and future research

There are some intrinsic limitations that affect the generalizability of the research findings. First, the regression model has not been validated using a live-case project. This may affect the general reliability of the proposed mathematical model. Second, the response rate is low, although it is generally adequate compared to other studies. In fact, the low number of responses may affect the applicability of the mathematical model on some projects. Third, the use of questionnaire survey presents some bias in the ranking of both the success criteria and CSFs. Lastly, the relationship between each category of CSFs and the overall project success as presented in Fig. 1 was not analysed.

Considering these limitations, it is recommended that future research should apply the predictive model to a PPP project procured in a developing country particularly those that shares similar economic and socio-political features with Ghana. The predicted success should be compared with the project success index, which can be calculated using the PSI equation (see Eq. 3) proposed by Osei-Kyei and Chan (2017b).

Further, future research should adopt the conceptual model and analyze thoroughly the relationship among the proposed six CSF categories and overall PPP projects success (i.e. PSI) using Structural Equation Modelling (SEM). This would provide in-depth insight and understanding on how PPP projects success could be achieved in developing countries.

Conclusion

Although CSFs and success criteria for PPP projects have been studied extensively by many authors, there has not been any attempt to establish a linkage between them. Moreover, past studies simply ranked CSFs without deriving a predictive model which incorporates the success criteria (i.e. success index) of PPP projects. Based on empirical data from Ghana, this paper developed a practical tool for predicting PPP projects success in developing countries. First, a conceptual model is proposed based on the theoretical assumptions of Lim and Mohamed (1999) on project success framework. The conceptual model consists of two component, CSFs and Success criteria. The CSFs component is further grouped into six broad categories namely Political, Economic, Technological, Social, Organizational and Managerial (PETSOM). Using the regression analysis technique, the conceptual model is tested to derive a mathematical model that can predict the success of PPP projects in developing countries. The regression analysis reveals three significant predictors of PPP projects success out of a broad range of CSFs. The best predictors include appropriate risk allocation and sharing, sound economic policy and right project identification. Various statistical tests including ANOVA, tolerance and variance inflation factor (VIF)), homoscedasticity and Durbin Watson tests confirmed the predictive accuracy, reliability and goodness of fit for the model. The substantive model is beneficial to practitioners and implementers in developing countries particularly Ghana because it will enable them to reliably quantify the likely success of their PPP projects prior to their implementations. Moreover, the

practical tool informs practitioners (i.e. clients and consortia) of the attributes that need to be carefully manage, to achieve the desired success levels of their PPP projects.

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Table 1. CSFs for PPP projects (Adapted from Osei-Kyei and Chan, 2015)

CSFs for PPP projects	Mladenovic et al, 2013	Liu and Wilkinson, 2013	Ng et al, 2012	Abdul – Aziz & Kassim, 2011	Jamali, 2004	Jacobson and Choi, 2008	Meng et al, 2011	Tang et al, 2013	Askar and Gab-Allah, 2002	Hwang et al, 2013	Tang and Shen, 2013	Raisbeck and Tang, 2013	Li et al, 2005	Gannon and Smith, 2011	Ozdoganm and Birgonul, 2000	Nisar, 2013	Dulaimi et al, 2010	Zhang, 2005a	Tiong et al, 1992	Tiong, 1996	Zhang, 2005b	Jefferies et al, 2002	Jefferies, 2006	Babatunde et al, 2012	Cheung et al, 2012	Chan et al, 2010	Kumaraswamy & Morris, 2002	Cheung (2009)
Appropriate risk allocation and sharing	X					X	X			X			X			X	X	X		X		X	X	X	X			
Strong private consortium		X	X							X	X		X			X	X	X	X	X		X			X			
Political/ government support				X		X							X	X	X		X	X						X		X		
Public/ community support						X							X	X				X				X	X			X	X	
Transparent PPP process	X				X			X		X	X		X	X												X		
Favourable legal and regulatory framework	X				X					X			X				X							X	X			
Stable macro-economic indicators	X	X															X	X						X	X	X		
Competitive tendering process	X			X			X																X	X		X		
High level of enthusiasm and willingness						X		X			X		X	X											X			
Clarity of roles and responsibilities				X		X		X		X	X															X		
Technology innovation		X															X		X	X		X						
Open and frequent communication				X		X	X	X			X																	
Detailed project planning	X			X		X															X			X				
Government providing guarantees		X	X												X									X		X		
Right project identification									X										X	X		X						
Long term demand for the project	X		X				X								X													
Clear project brief and design development					X			X				X											X					
Political stability	X																	X					X					
Mature and available financial market													X		X								X					
Reasonable user fee charges			X																	X	X							
Streamline approval process		X																				X	X					
Choosing the right private consortium																		X			X							
Sound economic policies													X		X													
Well organized and committed public agency										X			X															
Clear goals and mutual benefit objectives			X					X																				
Employment of competent transaction advisors						X	X																					
Reliable service delivery			X				X																					
Environmental impact of project																				X		X						
Existence of a PPP project champion																												X
Government providing financial support																												
Technology transfer																	X											
Public/community participation and coordination																X												

Table 2. Success criteria for PPP projects (Adapted from Osei-Kyei et al. 2017)

Success Criteria	Descriptions	Sources												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Profitability	A continuous income/ profit is received by parties during project operation		X									X		
Long-term relationship and partnership	Cordial relationship and well established coordination are instituted among stakeholders													X
Satisfying the need for public facility/service	An implemented PPP project satisfies fully the need for a public facility/service												X	X
Adherence to time	Project is constructed on/before time schedule for commissioning								X					
Adherence to budget	Project is constructed according to the estimated cost and it is without any operational cost overruns					X			X	X				
Reduced litigations and disputes	Contract litigations and disputes are minimized throughout the project lifecycle		X		X									
Reduced public sector administrative cost	Lower cost is incurred by the public sector in the administration of the project because major project risks are allocated to the private sector							X			X			X
Effective technology transfer and innovation	Technical knowledge and innovation are effectively shared among stakeholders particularly with local practitioners											X		
Local economic development	Project contributes to the economic development of the community within which the project is developed				X									
Environmental performance	Project does not affect the health and safety of occupants or the environment				X		X	X						
Reduced project life cycle cost	Lower life cycle cost is realised, which enhances the project's value for money													X
Reliable and quality service operations	Continuous and uninterrupted project services are provided and according to the satisfaction of users			X					X					
Meeting output specifications	Project meets the expected output standards/requirements and delivery	X							X	X				
Effective risk management	Risks are properly identified. The risk sharing and transfer mechanism are agreed and effectively implemented by the public and private parties										X		X	
Reduced public and political protests	The reduction of agitations and protests which often arise due to increases in tariffs, lack of transparency, corruption etc.							X						

1= Lam and Javed (2015), 2= Chan and Chan (2004), 3= Meng et al. (2011), 4 = Zhang (2006a), 5= Cheung et al. (2000), 6=Chan et al. (2002), 7= Zhang (2006b), 8= Dixon et al (2005), 9= Liyanage and Villalba-Romero (2015), 10= Li et al (2005b), 11= Mladenovic et al (2013), 12 = Liu et al (2015), 13 = Yuan et al (2009)

Table 3. Background of respondents

Demographics	Category	No.	Percentage
Sector	Academic	15	19.48
	Industrial practitioners (public and private sectors)	62	80.52
	Total	77	100
Practitioners years of research and/ or working experience in PPPs	≤ 5 years	29	37.66
	6 -20 years	47	61.04
	21yrs and above	1	1.30
	Total	77	100

CSFs for PPP projects Success criteria for PPP projects	Mean	Pearson correlation with PSI (dependent variable)	Mean	Correlation significance
Political/Government support	**3.91**	**0.259**	4.23	**0.023***
Political stability	4.43	0.156	4.14	0.175
Effective risk management			3.78	
Effective technology transfer and innovation			3.36	
Environmental performance			3.64	
Local economic development			3.56	
Long-term relationship and partnership			3.38	
Meeting output specifications			4.32	
Profitability			4.40	
Reduced litigations and disputes			3.55	
Reduced project life cycle cost			2.84	
Reduced public and political protests			3.49	
Reduced public sector administrative cost			2.96	
Reliable and quality service operations			3.87	
Satisfying the need for public facility/service			2.70	

Table 4. Mean scores of the set of 15 PPP projects success criteria in Ghana

Transparent PPP process	**4.69**	**0.336**	**0.003***
Competitive tendering process	**3.83**	**0.343**	**0.002***
Existence of a PPP project champion	2.95	0.063	0.585
Favourable legal and regulatory framework	**4.53**	**0.304**	**0.007***
Government providing guarantees	**3.42**	**0.308**	**0.006***
Well organized and committed public agency/department	**3.61**	**0.304**	**0.007***
Mature and available financial market	**3.64**	**0.374**	**0.001***
Sound economic policies	**3.52**	**0.424**	**0.000***
Stable macroeconomic indicators	**3.77**	**0.489**	**0.000***
Government providing financial support	2.52	-0.012	0.918
Technological innovation	**3.19**	**0.345**	**0.002***
Technology transfer	**3.30**	**0.309**	**0.006***
Public/community participation and coordination	2.97	0.127	0.272
Public/community support	3.13	0.173	0.133
Environmental impact of project	**3.40**	**0.395**	**0.000***
Clear project brief and design development	**3.57**	**0.378**	**0.001***
Reliable service delivery	**3.56**	**0.266**	**0.020***
Employment of competent Transaction Advisors	**3.51**	**0.293**	**0.010***
Choosing the right private consortium	3.47	0.148	0.200
Reasonable user fee charge	**3.31**	**0.239**	**0.036***
Streamline of approval process	3.34	0.150	0.192
Long term demand for the project	3.38	0.141	0.222
Right project identification	**4.00**	**0.440**	**0.000***
Detailed project planning	**3.75**	**0.414**	**0.000***
Strong private consortium	**3.25**	**0.297**	**0.009***
Appropriate risk allocation and sharing	**3.70**	**0.519**	**0.000***
Clear goals and mutual benefit objectives	3.39	0.139	0.229
High level of enthusiasm and willingness from parties	**3.66**	**0.362**	**0.001***
Open and frequent communication among stakeholders	**3.60**	**0.228**	**0.046***
Clarity of roles and responsibilities among parties	4.39	0.204	0.075

Table 5. Correlation values of CSFs with the success outcome (dependent variable)

*Significance at 5% (0.05)

Table 6. Model summary[d]

Model	R^2	Adjusted R^2	Std. Error	R^2 Change	Sig. F Change	Durbin-Watson
1[a]	0.269	0.260	0.498	0.269	0.000	
2[b]	0.364	0.347	0.468	0.095	0.001	
3[c]	0.450	0.428	0.438	0.086	0.001	1.829

Notes: [a]Predictors: (Constant), Appropriate risk allocation and sharing
[b]Predictors: (Constant), Appropriate risk allocation and sharing, Sound economic policies
[c]Predictors: (Constant), Appropriate risk allocation and sharing, Sound economic policies, Right project identification
[d]Dependent Variable: PSI for PPP projects (success outcome)

Table 7. ANOVA results for the optimum model (Model No. 3)

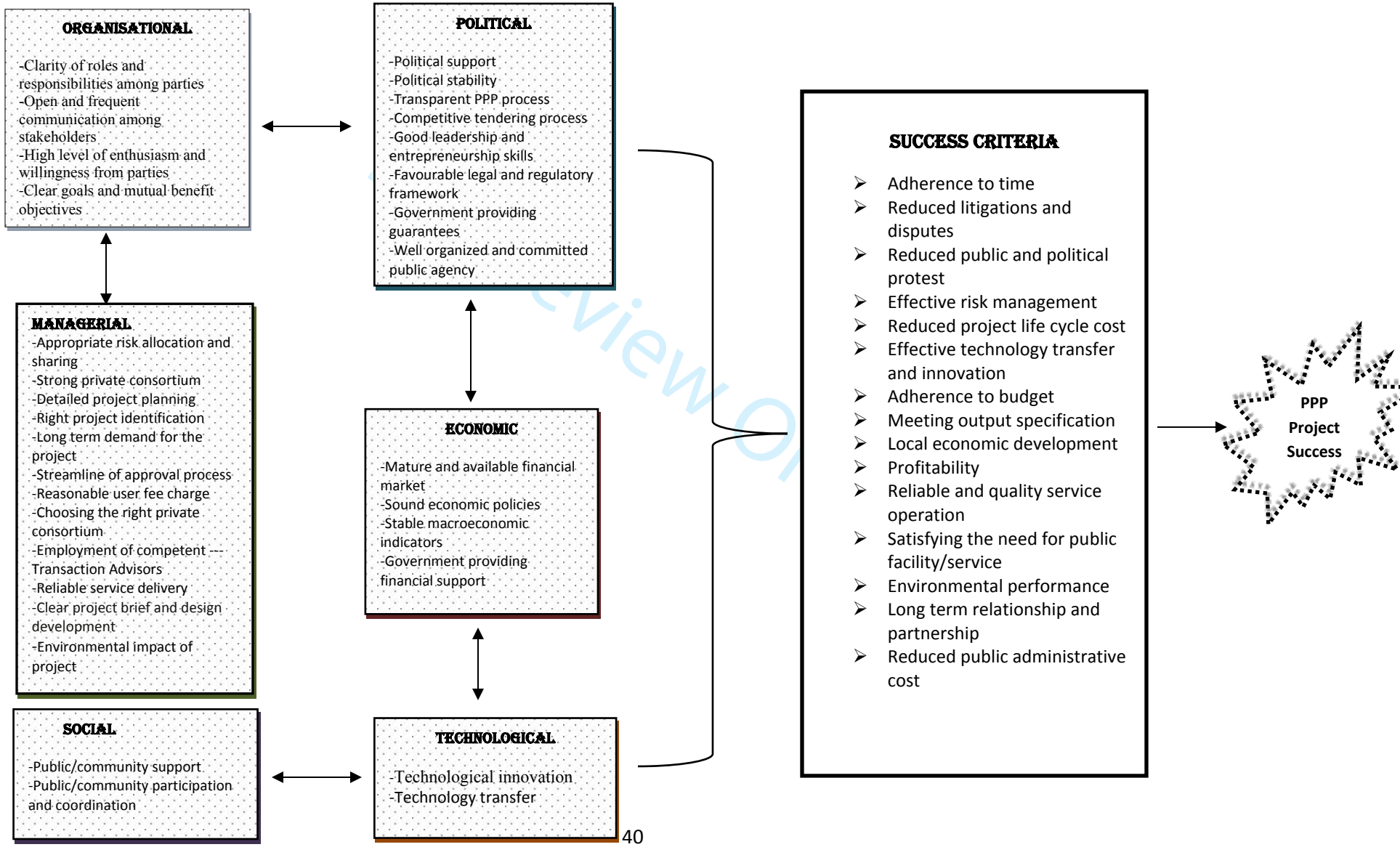
Model No. 3	Sum of Squares	Degree of freedom	Mean Square	F	Sig.
Regression	11.460	3	3.820	19.928	0.00
Residual	13.994	73	0.192		
Total	25.453	76			

Table 8. Regression results for Model to predict PPP projects success in developing countries

Variables	β	σ	b	t	Sig.	Tolerance	VIF
(Constant)	-2.705	0.358	N/A	-7.546	0.000	N/A	N/A
Appropriate risk allocation and sharing	0.257	0.068	0.353	3.784	0.000	0.866	1.155
Sound economic policy	0.239	0.069	0.312	3.485	0.001	0.942	1.062
Right project identification	0.228	0.068	0.307	3.375	0.001	0.911	1.098

Notes: Regression coefficient (β), Standard error (σ) of variable regression coefficient, Standardized regression coefficient (*b*) which represents the contribution of each variable to the model, Value if t-statistic (*t*), Significance of t-statistics (p-value), Tolerance for multicollinearity measure and Variance Inflation Factor (VIF) for multicollinearity.

Figure 1. Conceptual model for PPP projects success



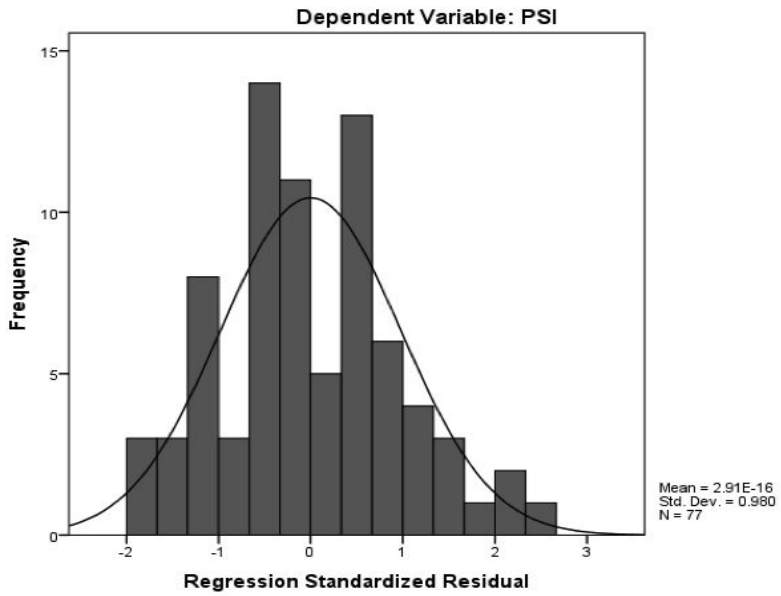


Figure 2. Histogram of standardized residuals

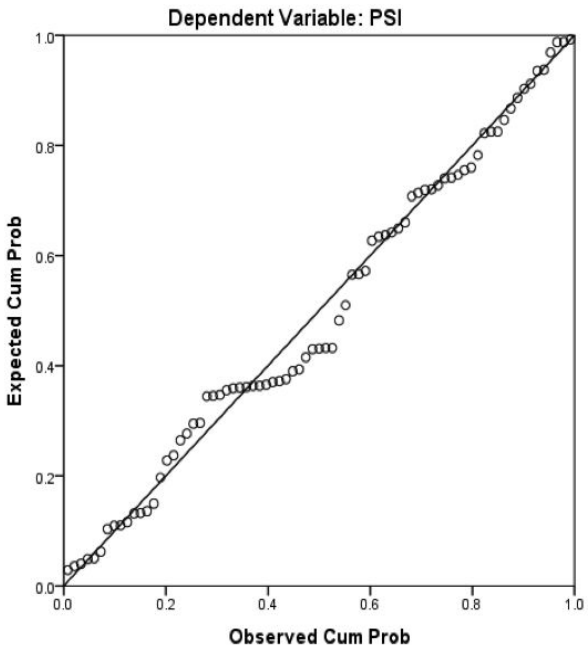


Figure 3. Normal Probability Plot

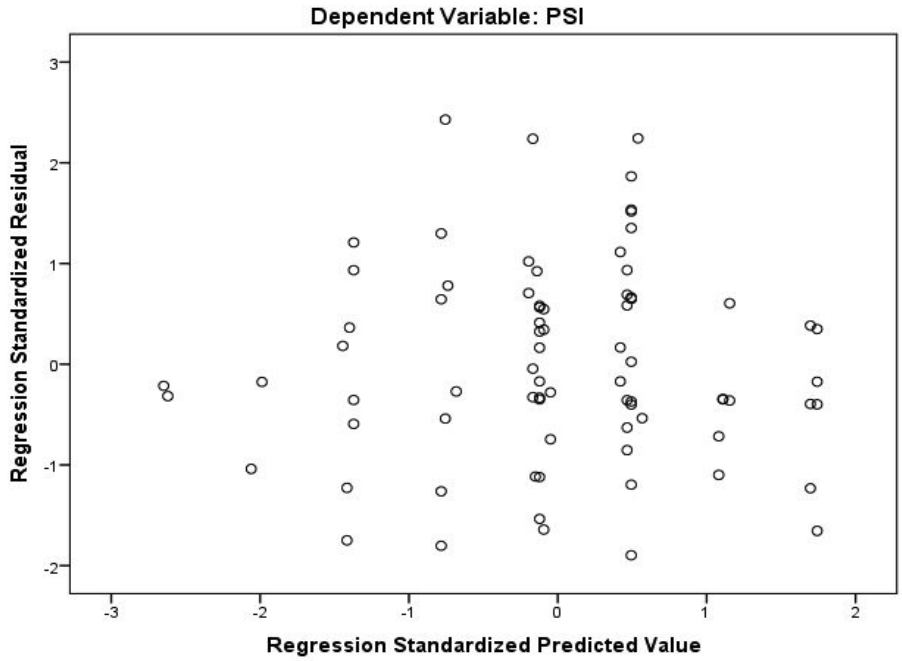


Figure 3. Scatter diagram