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DECISION SUPPORT SYSTEM FOR PUBLIC PRIVATE PARTNERSHIP INVESTMENT IN WATER PROJECTS

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Abstract: Developing positive cash flow projects depends on the inclination and ability of the customers to pay for the offered services. This paper presents an analytical system/method to help Public Private Partnership (P3) developers and investors to select the region or the area that has the affordability to pay back the loan using Gross National Income (GNI) and access to potable water. A decision making system that includes a model and four investment groups has been developed to categorize the countries into investment groups. The Data used in this paper were collected from 195 countries as well as the percentage of their respective populations that have access to potable water. K-means and Regression Analysis techniques have been used to build the investment groups and the decision making model. The developed system/method has been validate using real data of 40 countries through Average Validity Percent (89.5 %), and R-squared (85.0 %) which, show satisfactory results.

1 INTRODUCTION

A public–private partnership (PPP, 3P or P3) is an agreement that require cooperation between two or public and private entities to perform a long-term project (Hodge et al, 2007). The European Investment Bank (EIB) (2004), defines a P3 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 (PPIAF) states that a P3 “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” (PPIAF 2014). Cooperation between public and private entities exist for years. (Wettenhall, 2007; Wettenhall, 2010) However, recently, such cooperation is obvious throughout the world in multiple areas. (Hodge et al, 2007).

Researchers did not agree on the definition of a P3. (Marsilio et al, 2011) P3s is considered as a portfolio of agreements or a delivery method. (Hodge et al, 2007) As an agreements’ portfolio, it contains different options of contracts that are varied in financial funding, risk allocation, and transparency. As a delivery method, it separates the contract from complete government control and privatize it to some extent (Hodge et al, 2007; Marsilio et al, 2011). As a portfolio of agreements, it contains five different types of agreements as per UK's Private Finance Initiative (PFI) (Hodge et al, 2007; Marsilio et al, 2011; Weihe et al, 2006). Preference of an agreement type of the other varied between countries and over time.

Since P3 includes complex long-term partnership agreement with risk sharing between parties, it can be differentiated from other traditional delivery methods (Akintoye et al. 2003; Zhang 2004, Kwak et al., 2009).

Different professional look at P3 from different angles. Financial and engineering professionals focus on relative value- of-money (VfM) and project delivery while, politicians and public administrators consider it a mechanism to achieve government goals. Sharing risk between public and private entities is a well considered characteristic of the P3s. Utilizing private fund is a major consideration of such delivery method however, it was affected by the recession of 2008 (Hodge, 2016).

According to Weimer and Vining, "A P3 typically involves a private entity financing, constructing, or managing a project in return for a promised stream of payments directly from government or indirectly from users over the projected life of the project or some other specified period of time". Accordingly, P3 contracts can include some monopolies under its wings (Weimer and Vining, 2011).

With the complexity of contractual environment of the P3, studying its critical success factors (CSFs) is essential to get the project to success (Zhang, 2005) (Kwak et al. 2009). CSFs are defined as "the key areas of activity necessary to be focused to ensure competitive performance towards an organization's strategic goals" (Rockart 1982). The CSF method has been used in different fields such as construction, finance, information technology, and manufacturing. CSFs in P3s has been studied since the 1990s (Rockart, 1982; Boynton and Zmud 1984; Yeo 1991; Sanvido et al. 1992; Mohr and Spekman 1994). The CSFs for P3s are based on a number of characteristics: (1) robust private entity; (2) steady political situation; (3) fair legal system; (4) proper allocation of risks; (5) project financial feasibility; and (6) uncorrupted procurement procedure (Chan et al. 2010, p).

An examination of the studied CSF characteristics for P3s attentive to project success rather than the proper selection of an appropriate target market based on affordability (e.g., Tiong et al. 1992; Tiong 1996; Qiao et al. 2001; Abdel Azziz, 2007).

2 RESEARCH METHODOLOGY

This paper presents an analytical method and models to help P3 developers and investors to focus on the region or a country that has a potential and affordability to pay back the loan using Gross National Income (GNI) and access to potable water. This goal will be accomplished through fulfilling the following steps:

- Examine the current literature and previously established models to find gaps and lack of investment decision making models of P3;
- Collect the Gross National Income values for a list of countries, totaling 195 counties, and access to potable water from the World Bank projects.
- Classify the data sets into groups that are quite homogeneous in features based on a number of variables.
- Build a Regression model to predict a categorical dependent variable using GNI and access to potable water.
- Test and validate the established models to confirm their robustness in predicting and categorizing different countries for potential investment in P3.

3 DATA COLLECTION

Data utilized in this paper were collected from the World Bank. It included GNI per capita in 2015 at nominal values for 195 counties, and the percent of population with access to potable water. The measures of the social, economic and environmental wellbeing of a nation and its people are closely associated with its GNI per capita (World Bank, 1994).

Percent of population with access to potable water is a measure of the wastewater system of each country or financially independent state. The term was developed by United Nations Children's Fund (UNICEF) and World Health Organization (WHO) in 2002 in their efforts to evaluate the progress towards achievement of Goal Number 7 of the Millennium Development Goals (MDGs), which is ensuring environmental sustainability (WHO and UNICEF, 2017).

World Bank based on the GNI per capita groups countries into four categories, the different groups are the high-income countries, upper middle income, lower middle income and low-income countries. It does not use any of the amenities of life such as electricity, water, or improved sanitation as a measure. They are ranked from highest GNI per capita. Ranks, GNI per capita, and access to potable water of each group are shown in Table 1.

Table 1: Categories of countries rank, GNI per capita, and access to potable water (Sample)

Rank	Country	GNI per Capita (USD)	Access to Potable Water (%)
Azerbaijan	173	6560	87
Bulgaria	181	7480	99.4
Turkey	190	9950	94.9

4 BUILDING INVESTMENT MODELS

The first step will be data set classification into homogeneous groups in characteristics based on a number of variables using K-means through choosing the number of clusters k, assigns each data point to its closest centroid using a distance measure, and test the outliers using Grubbs Test. Then build and validate the Regression model.

4.1 Data Clustering

Cluster analysis is a suitable and most efficient way of grouping data into classes that are related based on their characteristics using certain variables. The resulting groups are referred to as clusters. Throughout the procedure analysis process will be denoted by the variable K. Whenever the variable K appears it denotes that the analysis has been calculated based on the cluster method. Below are the steps as following:

1. Select the number of clusters k and inscribe a set of information of patterns X=(x1, …, xn). Secondly, choose the initial values for K cluster center matrix V(0) from the set of given data. However, the choice of k is always indefinite since it is drawn from different scales and shapes of a point of distribution. A conditional increase in the value of K will lead to the reduction of error in cluster calculation. However, zero error is calculated separately for each cluster which enables the value of k to balance between the maximum accuracy and the maximum data comprehension per a single cluster.

2. This step requires the assigning of data points. This is achieved by taking the points closest to the centroid which must have been initially calculated. The membership function m (Cj xi) is calculated for every pattern xi in every cluster Cj.

3. Test the outlier using the Grubs test, which is an outlier test that detects one outlier in a pile of data that is in line with the normal distribution. It is commonly referred to as the maximum non-residential test (Grubbs, 1969)

4. Continues steps 3 and 4 until the observations are not reassigned. The final partitions are shown in Table 2.

These clusters will help the developer in identifying countries with potential to invest in the energy sector with a public private partnership delivery method. Table 3 shows clusters interpretation.

Table 2: Final Partition

Cluster	Number of observations	Within cluster sum of squares	Average distance from centroid	Maximum distance from centroid
Cluster1	26	5.966	0.385	1.202
Cluster2	98	13.801	0.330	1.057
Cluster3	44	7.646	0.383	0.783
Cluster4	26	48.611	0.840	5.908

4.1 Regression Modeling

For this stage, Minitab statistical software is employed for the construction of regression. The software is mainly used because of its capabilities to churn various functions such as analysis, variance, and correlation not to mention its user-friendliness. The best subset regression technique is used to determine the best model which must comprise several predictors. Research has been done on the four investor groups to determine their correlations with various clusters. R-square is used to choose the best model which should have the highest R-square. The fourth group has been excluded. R-square (85.48 %), R-square adjusted (84.24 %), and R-square predicted (84.24 %). The best fit model is carefully chosen by considering a number of measures. These measures are the highest R-square, R-square adjusted, and R-square predicted. Therefore, the selected model is as following:

Investment Group = - 0.084 + 0.0184 **% Population with Access to Water** + 0.0341 **GNI per capita** (1)

Table 3: Cluster Interpretation

Cluster	Definition
G1	Group of countries with low GNI and low access percent to potable water
G2	Group of countries with Medium GNI and high access percent to potable water
G3	Group of countries with low GNI and medium access percent to potable water
G4	Group of countries with high GNI and high access percent to potable water

4.2 Model Validation

The model has been verified utilizing statistical, logical, and practical methods to warrant the meticulousness and effectiveness in forecasting the performance. A set aside points of data, that represents 20% of each group, were randomly selected to be used for model validation and adequacy to represent the remaining data points. These points were not used in developing the model. Average Validity Percent (AVP) is used to identify the predictability percentage of the model compared to the actual data points (Zayed & Halpin, 2005). The Average Invalidity Percent (AIP) is used to specify the error in predictability of the model. The AVP value and AIP are 89.49%, and 10.51% respectively. These results are satisfactory. Figure 1 presents the variance between the predicted values from the model and actual ones. The comparability of these values is clear from such graphical representation. The percentage of error will be calculated as the following:

Average Validity Percent (AVP) % = (Predicted Value /Actual Value) * 100/Number of observations (2)

Average Invalidity Percent (AIP) % = 100 − AVP % (3)

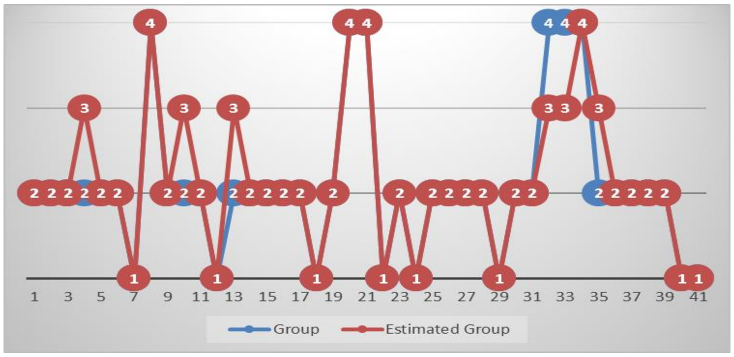

Figure 1: Actual vs. Predicted Investment Group

5 CONCLUSION AND RECOMMENDATIONS FOR FUTURE STUDIES

This research has determined four groups for investment and built a model to select the best candidate country for investment using Public Private Partnership (P3). The presented research shows the effect of GNI and percentage of population with access to potable water on the choice of the candidate country for investment. The GNI per capita is slightly higher than the percentage of population with Access to potable water. The developed model helps the investors and decision makers to understand, analyze, and decide depending on solid base which country or group of countries to invest using P3. This research limitations and future work are: (1) Collect data from different sources rather than the World Bank and (2) Investigate more factors that might affect the decision of the investor but without making the model more complex to be used by practitioners.

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