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External Business Drivers of Concession Period in Transport PPPs: An Empircal Investigation

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Abstract

Despite the abundance of papers on establishing the optimal concession period for Public Private Partnerships (PPP) from the public procurement perspective, the impact of external factors influencing the duration of the concession period of PPP projects is scarcely explored in the PPP literature. In this context, this research conducts a statistical analysis using multivariate regression analysis (MRA) and analysis of variance (ANOVA) to evaluate if a set of key factors may influence the duration of the concession period of a PPP transportation project. The outcomes of the model show that the area of the world wherein the project is developed and the regulatory framework of the country significantly impact the definition of the concession period. The proposed study paves the way for understanding the crucial levers influencing the duration of the concession period to increase the value associated with a PPP initiative.

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Keywords: Public Private Partnership; PPP; Concession Period; Multivariate Regression Analysis; Analysis of Variance

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1. Introduction

Public-Private Partnerships (PPPs) serve as a strategic tool in public procurement, aiming to ease the fiscal burden on the public sector while entrusting duties to private entities. These initiatives play a pivotal role not only in addressing infrastructural needs but also in driving economic growth by tapping into the specialized knowledge of the private sector [1]. Contracts for PPP projects are typically established between public authorities and Special Purpose Vehicles (SPVs) dedicated to infrastructure and service provision [2]. These collaborations are anticipated to yield efficiency gains by distributing risks, leveraging private sector resources, and consolidating responsibilities, ultimately resulting in reduced lifecycle costs, improved project delivery, and optimized maintenance [3] Moreover, PPP arrangements entail the procurement of services from the private sector rather than solely acquiring assets, fostering cooperation and utilizing private sector financing and expertise to achieve cost efficiency. By assigning risks to the party best equipped to manage them, PPPs facilitate effective cost management, timely project completion, adherence to quality standards, efficient operations, and risk mitigation. Additionally, PPPs empower governments to introduce new infrastructure and services with minimal initial capital investment [4].

A critical aspect inherent in PPP contracts is the concession period, which dictates the duration during which the SPV is responsible for financing, constructing, maintaining, and operating a public asset before transferring it back to the public sector [5]. It has been demonstrated that its determination is a challenging issue [6], it is a crucial lever of successful PPP projects [7], and it carries significant implications. Longer concession periods increase risks and uncertainties associated with social, political, and economic conditions, thereby potentially impacting the project's outcomes [8]; [9]. Additionally, prolonged concession periods lead to higher operational expenses (OPEX) for the SPV due to increased labor costs, upgrades, and maintenance requirements [10]. Such extended periods may also require higher capital expenditures (CAPEX) to ensure long-term performance enhancements [11]. Moreover, extended concession periods result in longer payback periods for the SPVs, potentially posing challenges to public funding in the future [12]. On the contrary, shortened concession periods brings the private sector’s worries about not repaying its debts and loans and earning the expected profit [13].

In literature, a lot of works focusing on the definition of the duration of the concession period have been published [14] ; [15]. In addition, literature mainly considers the internal project aspects in the design of the concession period [16]. On the contrary, there is a scarcity of papers analyzing the role of external business environment factors in the concession period definition. Understanding these factors could be crucial for the success of PPP projects. Therefore, this paper proposes a statistical analysis using multivariate regression analysis (MRA) and analysis of variance (ANOVA) to investigate potential relationships between a set of contextual factors and the duration of the concession period for PPP initiatives carried out in the transportation sector at the international level.

The structure of the paper is as follows. First, an overview of relevant pertinent literature about the PPP concession period is shown. Then, the methodology adopted is described together with the potential external factors. After that, the results of the empirical model are presented and finally, the discussions and conclusions are traced.

2. Literature Review

In the transportation sector, PPP has been largely used to improve the efficiency of the service delivered and the quality of the infrastructure [17]. In conventional transportation PPPs, the long term fundings typically hinge on direct tolls collected from users during the operational phase. In this funding scheme is important to carefully estimated the customers’ demand to guarantee acceptable levels of returns for the private partners during the concession period [18]. Nonetheless, in response to public apprehensions, alternative payment schemes have surfaced, leaning more towards government financing as opposed to user contributions. Therefore, PPPs are commonly funded through a combination of user fees and government payments, which are closely related with the concession period [19].In literature a lot of papers have been published about the appropriate definition of the concession period. Abbasianjahromi and Naserkhaki (2023) [14] presented an Agent-Based model for PPP contracts by proposing several scenarios. Song et al. (2021) [7] developed a simulation model for optimizing the duration of the concession period. Similarly, the simulation model proposed by Jin et al. (2019) [12] estimated the different value of Net Present Value that were obtained for different concession period in PPP transport projects. Nguyen et al. (2021) [10] conducted an empirical

analysis focused on the Decoupled Net Present Value for providing an integrated model for deriving concession periods of any PPP projects.

Several aspects might have an influence on the definition of the concession period. The area of the world on which a transportation PPP project is carried out is expected to influence the concession period. Regulatory frameworks, market dynamics, infrastructure needs, socio-political stability, and environmental factors all play crucial roles in shaping project finance, which impacts the length of the concession period [20]. Understanding these regional differences may play a significant role for the concession period of transportation PPPs.

The GDP of a country may play a significant role in determining the concession period for transportation PPPs. It influences the financial viability, risk management, infrastructure investment needs, and public financing capabilities associated with these projects [21]. Overall, the economic context affects multiple facets of a PPP agreement, which ultimately may impact the concession periods.

Furthermore, the regulatory quality (RQ) of a country may have profound implications for the concession period in transportation PPPs. This indicator, provided by World Bank is intended to capture perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development [22], which ultimately may affect the definition of the concession period. It influences project stability, efficiency, financial predictability, public trust, and compliance with environmental and safety standards [23], which ultimately may impact the concession period [24].

The Population in the Area is considered a potential factor that may affect the concession period. The size of the population in the project area directly influences the potential demand for the infrastructure, leading to increased traffic volumes, as there are more people needing transportation [25]. An infrastructure in a densely populated area may experience higher usage and potentially require more frequent maintenance. This can impact the concession period, as the private entity may need to invest more in upkeep or even expansion to accommodate the demand. The population density also affects the revenue generated through tolls or user fees, influencing the overall financial viability of the project and, consequently, the length of the concession period. Moreover, a larger population usually requires more extensive road systems or additional services, such as advanced traffic management or rest areas, impacting the time required for the design, construction, and integration of these additional features. Complementary, areas with a higher population may have more stakeholders with diverse needs and interests. Addressing these stakeholder concerns and ensuring their involvement in project decisions could lead to longer negotiation and coordination periods, potentially extending the concession period. The catchment population has been used as an influencing variable for project outcomes in previous studies [26].

This literature review shows that there is a relevant stream of study in the field of the PPP, and on the relationships among the most significant aspects that are considered. These relationships are also studied in quantitative terms. However, there is a lack of research focused on the combined effects external factors influencing the definition of the concession periods. Therefore, to bridge this research gap, this paper proposes a statistical analysis with the aim of studying potential relationships between a set of contextual factors and the duration of the concession period for PPP transportation infrastructure initiatives.

3. Methodology

The aim of this study is to identify the main potential environmental factors that might impact on the definition of the duration of the concession period. To this end, a dataset has been retrieved from primary sources of data namely World Bank and PPI Database, and an empirical approach has been adopted. The PPI Database was selected for its reliability as the most comprehensive dataset on PPP projects in developing countries, featuring consistently updated annual data. After identifying the procured projects, any missing parameters were supplemented with public information available from each respective country. The selection process for the environmental factors resulted from the review of existing literature identified conditions influencing the length of concession periods. Consequently, the variables were selected based on scholarly evidence (as explained in the Literature Review section) and the availability of project data.

A multivariate regression analysis (MRA) and an Analysis of Variance (ANOVA) have been carried out. Specifically, the last one was adopted with categorial factors. In fact, this empirical method is broadly used for identifying the differences among a set of categorical qualitative variables on a continuous dependent parameter [27].

In addition, the MRA was selected since it is broadly adopted for capturing dependencies between a dependent variable and a set of other independent continuous predictors [28]. To prevent collinearity, the correlation among independent variables is tested by calculating each independent variable's Variance Inflation Factor (VIF). A low VIF value indicates the absence of multicollinearity in the sense that the independent factors are not related between each other, and the outcomes of the model can be considered reliable. Conversely, a variable with a high VIF value demonstrates a significant collinearity level, which indicates that this variable might bring misleading results and it can be discarded. For both MRA and ANOVA, it is worth noticing that the level of significance of every investigated relationship can be referred to as the p-value notion. It ranges between 0 and 1 and if it is lower than a critical threshold (in most cases equal to 5%) the independent variable can be considered significant. It can be stated that the notion of significance can be associated with the reliability of the relationship instead of its strength.

4. Results

Multiple methods were used to collect data on the transportation PPP projects analyzed. This included a detailed analysis and synthesis of various resources including academic papers, online records, and public databases. The analysis resulted in the selection of 257 transportation PPP projects procured in 58 countries in Europe, Africa, and Asia, cumulatively valued at $152 billion. The data collection process focuses on gathering information from all transportation PPP projects undertaken in each of the 58 countries included in the PPI database. Based on the information gathered, Table 1 present an overview of the statistical distribution of variables considered in the present study, including quartile and standard deviation figures. Figure 1 shows the overview of the distribution of the categorical variables hypothesized significant for the concession period.

Table 1. Descriptive Statistics

Variable	Unit of measurement	Mean	Standard Deviation	Minimum	Median	Maximum
Concession Period	Years	24.21	9.95	2	25	75
Population of the area	Million inhabitants	5.13	6.11	0.01	2.4	27.2
Regulatory Quality	-	-0.17	0.815	-2.12	-0.33	2.02
GDP	USD	4,11E+11	6,11E+11	546885223	1,09E+11	3,06E+12

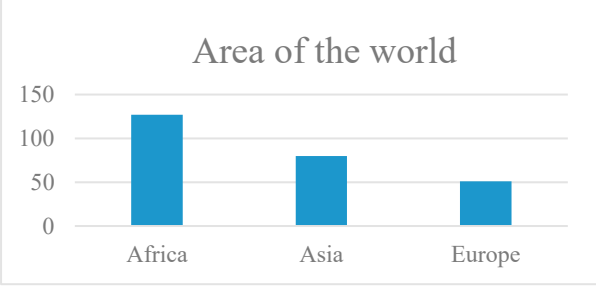

Fig. 1. Geographical Distribution of the PPP projects

The analysis of the results provides a significant understanding on the main drivers of concession periods in transportation PPPs based on objective performance measures (i.e., those derived from hard project data) based on a comprehensive sample involving over 257 projects procured in Europe, Africa, and Asia. The initial part of this section centers on the examination of multicollinearity, normality tests, and regression studies to pinpoint the significant factors influencing the relative scale of PPP programs. The subsequent part details the ANOVA results. Table 2 shows

the results of the regression model. The columns report the coefficient of every factor considered, the standard error of the coefficient, the T-Value, the P-value and finally the level of VIF. The absence of multicollinearity among the predictors allows to include all of them in the model.

Table 2. Outcomes of the Regression Analysis

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	25,348	0,926	27,37	0	
Population of the area	-0,152	0,103	-1,48	0,14	1,09
Regulatory Quality	2,899	0,946	3,06	0,002*	1,61
GDP	0	0	0,44	0,657	1,68

The Residual plots graphs of the regression model (Figure 2), show that residuals can be considered normally and randomly distributed. This allows to consider the developed model appropriate. In fact, if the assumptions about the validity of the model are valid, a plot of the residuals against the predicted values will have a random distribution [29].

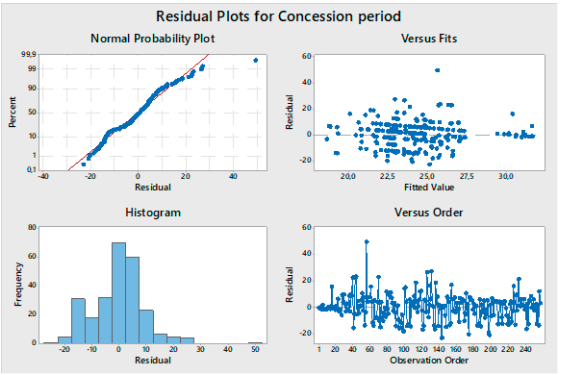

Fig. 2. Residual Plots of the Regression Model

In Figure 3 the Interval Plot related to the ANOVA model is presented. This plot shows that the average duration of the concession period for Europe is significantly longer compared with the other ones of Asia and Africa. This outcome is confirmed by the p-value resulted from the test that is equal to 0.000. It means that it is possible to state with an acceptable level of confidence that at least one of the concession period durations of the three area of the world is different compared with the other ones.

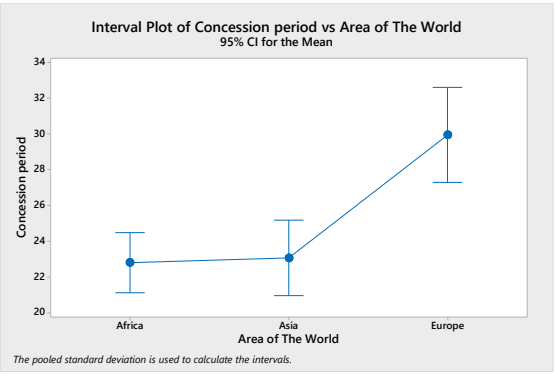

Fig. 3. ANOVA Interval Plot

5. Discussions and Conclusions

This study examined several critical factors influencing the concession period in transport PPPs at an international level. The results of the empirical model show that the duration of the concession period is not affected by the population within the area wherein the project is developed, and by the GDP of the country. The Population in the Area was determined to lack significant influence on the concession period. This finding takes a step further than extant literature that overlooked the catchment population factor. Previous literature identified the population within the area of the projects as a significant driver of the concession period in social infrastructure in developed countries [11]. On the other hand, the proposed research demonstrates that this pattern is not generalizable when considered transportation infrastructure in a larger context involving multiple countries in multiple regions at different levels of development. For this reason, the proposed study advances this understanding by extending the analysis to the concession period. This finding can be interpreted as a higher concentration of potential end users within the vicinity would lead to heightened revenues from either toll collection or public payments, thereby averting the need for an extension of the concession period, irrespective of the magnitude of CAPEX investments. Furthermore, findings demonstrated that the GDP is not significant for the concession period meaning that concession periods might be more influenced by specific project risks rather than by the broader economic context indicated by GDP. Projects with higher construction risks, technological complexities, or uncertain revenue streams may necessitate longer concession periods, irrespective of the country's economic status or specific infrastructure category. Complementary, industry standards and common practices within the PPP transportation sector make the concession periods less variable across different GDP contexts or infrastructure types. Conversely, the RQ and the area of the world significantly impact the definition of the concession period. Significant differences appear among the different areas of the world taken into account. In particular, the longer concession periods related to European PPP projects might be due to lower levels of risks in European countries. As a consequence, private investors are more willing to accept longer concession periods associated with higher levels of uncertainty. In addition, European countries that are more developed typically require more operations standards with consequent impact on operational expenditures and in turn longer concession periods. Finally, the positive impact of the RQ is coherent with the previous result. More developed countries, with more effective and transparent regulatory framework represent more favorable environments for undertaking private investments. This means that the success and structuring of transportation PPPs rely more on regulatory and regional factors than on the broader economic context, which may explain private investment in regions with less stable economies whenever there is a robust regulatory framework conducive to PPPs.

This study's findings contribute to the theoretical understanding of various external business factors influencing the concession period in transportation PPPs across multiple geographical regions, and national regulatory quality while also offering practical insights for both SPVs and governmental entities involved in these projects. The selection of these indicators in developing the study was completing according to a deep literature review process. In fact, the catchment population can be considered as a proxy for the demand of the service that the PPP projects provides, the RQ might be referred to the business environment wherein a private operator could invest his/her money and finally the GDP affects the financial risk and the project viability, with relevant effects on the definition of the CP.

These findings have significant implications for policymakers, project developers, and stakeholders involved in road PPPs. Understanding the impact of different factors on the concession period can lead to more informed decision-making, better risk allocation, and improved project planning. However, there are limitations to this study. In particular, the study does not consider dynamic factors such as changes in demand, technology, or external economic shocks that may influence concession periods ex-post. Furthermore, while the study provides valuable insights, its focus on selected geographic regions limits its generalizability on a global scale. Nevertheless, it serves as a first attempt to understand the impact of external factors on project dynamics and provides a basic framework for future research to broaden its scope and enrich its findings.

Therefore, future research is needed to explore the long-term dynamics of concession periods and to examine the implications of these findings in a broader context. Then, additional studies should investigate the effects of different payment mechanisms on project outcomes beyond concession periods, such as project performance, public cost, and user satisfaction, could provide a more comprehensive understanding of the trade-offs involved. Finally, a comparative

analysis across different regions and sectors could help identify the contextual factors that drive the relationships observed in this study. Overall, addressing these research gaps will contribute to more efficient and effective PPP agreements and enhance the outcomes of future infrastructure projects.

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