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Determinants of private investment contracts in the basic sanitation sector: evidence for developing countries

Resumo: O investimento em infraestrutura, incluindo o acesso universal aos serviços de água e saneamento, é crucial para melhorar a qualidade de vida e promover o desenvolvimento econômico. O acesso à água potável e ao saneamento adequado é particularmente importante para a saúde pública. Este artigo, baseado no trabalho de Yehoue et al. (2006) e Sharma (2012), explora os factores que determinam o número de contratos de investimento privado no setor do saneamento básico. O estudo emprega uma análise empírica, utilizando um painel de países em desenvolvimento durante o período de 2003-2016, e emprega o estimador de contagem Binomial Negativa Inflada de Zeros (ZINB) para examinar o número de contratos no setor do saneamento. Adicionalmente, para análise de robustez, analisamos também os modelos Binomial Negativo, Poisson e Poisson Inflada de Zeros (ZIP). Os resultados do estudo indicam que o ambiente macroeconômico, o investimento estrangeiro e o ambiente político são os principais fatores que influenciam o número de contratos de investimento privado no setor.

Palavras-chave: Investimento Privado; Infra-estrutura; Saneamento Básico.

Abstract: Investment in infrastructure, including universal access to water and sanitation services, is crucial for improving the quality of life and promoting economic development. Access to clean water and proper sanitation is particularly important for public health. This article, based on the work of Yehoue et al. (2006) and Sharma (2012), explores the factors that determine the number of private investment contracts in the basic sanitation sector. The study employs an empirical analysis, utilizing a panel of developing countries over the period of 2003-2016, and employs the Zero Inflated Negative Binomial (ZINB) counting estimator to examine the number of contracts in the sanitation sector. Additionally, for robustness analysis, we also analyze the Negative Binomial, Poisson, and Zero Inflated Poisson (ZIP) models. The results of the study indicate that the macroeconomic environment, foreign investment, and political environment are the key factors that influence the number of private investment contracts in the sector.

Keywords: Private investment; Infrastructure; Basic Sanitation.

Classificação JEL: R42; H54; C01.

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1. Introduction

The responsibility for providing infrastructure services to meet the needs of the population lies with government authorities. However, since the late 1980s, many developing countries have turned to private sector investment in infrastructure as a solution to budget deficits and a means of promoting investment and economic growth. According to the World Bank, investment in water and sanitation in developed countries between 1990 and 2016 amounted to \$80.901 billion dollars across 996 infrastructure projects.

The investment in infrastructure is vital for improving the quality of life for the population. Basic sanitation is a crucial aspect of individual well-being, and a lack of access to clean water and proper sewage treatment can have a detrimental effect on public health and hinder sustainable development. The universal provision of water and sanitation services is particularly important due to the impact on public health. A report from the World Health Organization in 2014 states that for every dollar invested in water and sanitation, \$4.3 is saved in healthcare costs globally.

Given the high initial investment required for infrastructure, private sector participation has been encouraged by governments through alternative management arrangements, such as public-private partnerships, privatizations, and concessions. These methods aim to finance infrastructure investment projects and improve overall well-being. Empirical studies have advanced understanding of these contractual arrangements and are a valuable tool for public policymakers in designing contracts and addressing potential contingencies that could lead to contract failure.

In this scenario, due to the high initial investment needed in infrastructure, the participation of private investors has been stimulated by governmental organizations in alternative managerial arrangements in order to finance infrastructure investment projects and to reach a higher level of well-being⁵. In the context of contract models, privatizations and concessions, such as public-private partnerships, are some alternatives adopted by governments to fill the gap between fiscal restraint and demand for infrastructure to manage. Unlike privatization, in which the asset is sold to the private agent and, consequently, the asset's ownership changes, the concession contracts, although they generally have different rules among countries, have as main characteristic a long-term contractual modality, aiming to leverage infrastructure investments.

In this context, empirical studies such as: Chong et al. (2006); Yehoue et al. (2006); Wang et al. (2011); Sharma (2012); Fernandez et al. (2015); and Pusok (2016); have advanced in the understanding of these contractual relations. Thus, the theoretical and empirical study of these contractual modalities is an important factor for public policymakers, helping as a fundamental instrument for contractual design, taking into account possible contingencies that could lead to contract failure. In addition, contracts are generally classified as incomplete and long-term failures may be unpredictable.

Following Yehoue et al. (2006) and Sharma (2012), this article aims to identify the determinants of the number of contracts for the water and sanitation sectors in developing countries. We use a panel for developing countries from 2003 to 2016. Our database focuses on global development indicators, governance indicators and private participation in infrastructure investments (Private Participation Infrastructure Data Base - PPI), provided by the World Bank.

This study contributes to the literature by analyzing the basic sanitation sector for developing countries, seeking to investigate the determinants of the number of contracts (dependent variable) in this sector. Using panel data count estimators, we propose a new variable to control for the excessive number of zeros, since when the country does not have the contract information in a given year, it assumes the value of zero, which

⁵ According to the database provided by *Private Participation in Infrastructure (PPI)*. <<http://ppi.worldbank.org/>>.

can be explained by long-term concession contracts and the fact that a contract might be in place at that moment.

Thus, based on the instrument proposed by Acemoglu et al. (2014), which considers the spillover effects of democracy in neighboring countries, our variable is based on the premise that the concessionary practices of countries of the same region, that is, that share borders, can generate spillover effects on neighboring countries, reducing likelihood of not having contracts and inducing them to adhere to contractual arrangements.

Unlike the literature, the empirical part of the paper uses the Zero Inflated Negative Binomial (ZINB) model, with regional, income and temporal effects, to solve possible problems caused by counting regressions with an excessive number of zeros. In addition, variables related to foreign investment are used and the estimates generated by Poisson and Negative Binomial models with random effect are presented for analysis robustness purposes.

In short, the results found in the estimates indicate that the channels of a stable macroeconomic environment coupled with foreign investment and the political stability of nations are preponderant for the attractiveness of private investors to the increase in the number of contracts in the sector. In addition, our control variable for the excessive number of zeros has a strong overflow effect on all estimated models, which reduces the likelihood of neighboring countries not having contracts in the water and sanitation sector. That is, the fact that border countries have concession contracts reduces the probability of Brazil, for example, in approximately 70% when we estimate with an income dummy, that the country does not have contracts in the sector.

Following this introduction, in section two, we present the literature review that discusses the importance of the basic sanitation sector and the possible determinants of private investment. In section three, we present the hypotheses to be tested and the channels for specification of the empirical models. In section four, the data and the empirical strategy used are described. In section five, the results are described and discussed. Finally, in the last section, are the final considerations

2. Literature Revision

There is a vast literature on the determinants of private investments in infrastructure, such as the works of Hart et al. (1997); Hart, (2003); Harris, (2003); Bennet and Iossa, (2006); Engel et al., (2009); Iossa and Martimort, (2012); Iossa and Saussier, (2018). However, there are few empirical studies we are aware of that quantify the efficiency and the determinants of infrastructure investment in the use of concession contracts at an aggregate level for developing countries regarding the provision of water and sanitation services.

The provision of basic services, such as education, health, security and infrastructure, are the responsibility of government authorities. Basic sanitation is essential for the well-being of the population, where the lack of this provision with inadequate access to drinking water and sewage treatment directly affects public health, negatively influencing economic development and creating a favorable environment for diseases due to poor conditions. In line of this, a massive investment that fills this serious gap between provision and adequate access may significantly reduce diseases related to lack of sanitation and, especially, infant mortality (FUJIWARA, 2005).

According to the World Health Organization's (WHO) report of 2014, for every dollar invested in water and sanitation, US\$ 4.3 in health costs are saved worldwide. In this way, adequate provision of services in this sector may reduce the need for increased health care spending related to illnesses stemming from the lack of adequate access to

services, which is quite common in developing countries.

In this context, the universalization of water and sanitation services is of great importance for sustainable development. According to the United Nations, developing countries have until 2030 to meet the targets set by the Sustainable Development Goals (ODS) agenda. Among the goals is the ODS6 for water and sanitation sector, with the objective of ensuring adequate access to safe water and sanitation for all and increasing the efficiency of the use of treated water in all sectors. Thus, infrastructure investments need to have a substantial increase in these economies in order to support economic growth and meet environmental goals related to preservation (IOSSA and SAUSSIÉ, 2018).

The resources collected by governments through taxes should be transferred largely to meet the demands for basic services. However, it is important to note that in developing countries, on average, financial resources for infrastructure investments are scarce. High growth rates may attract more investors, increasing demand for infrastructure and thus promoting partnerships among private companies (RESIDE, 2009). According to Acemoglu and Robinson (2010), differences in economic growth rates may have as a factor the heterogeneity of the institutions of each country. That is, the difference in growth among nations may be due to institutional problems⁶.

Since the late 1980s, many developing countries have allowed private sector investment in infrastructure sectors, in order to reduce budget deficits, and expecting to foster investment and economic growth (TRUJILLO et al., 2002)⁷. To eliminate infrastructure deficiencies and achieve a higher level of well-being, the participation of private investors in alternative organizational arrangements has been stimulated by governmental organizations in order to finance investment projects in infrastructure⁸.

In this sense, the entry of the private sector may help the end of this vicious circle, since it tackles its main aspects such as low tariffs, management inefficiency, obsolete business practices and the mix up between politics and the internal management of firms (FERREIRA, 2007). Thus, fiscal restraint serves as a lever for the emergence of new arrangements of public services contracts and a transfer of responsibility to private partners (GUASCH, 2004).

As Sharma (2012) points out privatization is not adequate in infrastructure projects due to the complexity of management and intensive capital⁹. According to Yehoue et al. (2006), mutually beneficial partnerships between the public and private sectors may be important and private companies cannot have the responsibility for building and/or providing public infrastructures independently. In line with this view, we emphasize that public interest does not necessarily have to be attended only by public companies. In administrative terms, the responsibility for providing the services is public, but the management may be public or private. In these cases, the local authority remains partially responsible for the provision of services, while the private agent is in charge of the infrastructure and maintenance of the public good.

It should be noted that, for the purpose of this study, the main difference between public and private management lies in the incentives to which each one submits. Under private management, incentives can lead to cost minimization and, consequently, to the improvement of the quality of the services offered. On the other hand, in the public sector, incentives can be linked to political interests, stimulating rent-seeking¹⁰, and promoting the redistribution of resources from society to these groups through the use of the political system.

In the meantime, it should be noted that incentives for corruption gains may occur in both public and private sectors. The difference is that the private agent has more incentive to seek profits, in some contractual arrangements, they take all risk. Thus, incentives in the private sector may reduce costs and improved service quality. It should

⁶ According to the database provided by *Private Participation in Infrastructure* (PPI). <<http://ppi.worldbank.org/>>.

⁷ According to Gregório and Lee (1999), the lack of good institutions slows down economic growth in many countries.

⁸ According to the database provided by *Private Participation in Infrastructure* (PPI). <<http://ppi.worldbank.org/>>.

⁹ Projects in infrastructure possess the need of a high initial investment, without predicting future returns, which may discourage private companies from engaging in the privatization process. In addition, there are problems with transparency and difficulty in monitoring the service by the public agent, responsible for the provision of infrastructure services. Kishimoto's (2017) study details the experience of cities that have resorted to privatizations in the water and sanitation sector in recent decades and are reestablishing companies in this sector.

¹⁰ According to Tullock (2005), rent-seeking is the use of resources with the aim of generating income for a given group, and the economic incomes themselves come from some activity that has negative social value.

be emphasized the importance of property rights, since residual control rights determine who has the authority to approve changes in the process or innovations related to the asset (HART, 2003; IOSSA and MARTIMONT, 2012).

In the context of contractual models, privatizations, and concessions, such as public-private partnerships, are some alternatives to bridge the gap between fiscal restraint and demand for infrastructure, according to the institutional constraints of each country, to manage activities previously provided by the public agent. It is recurrent to the association of concession contracts and public-private partnerships with privatization. Given this, it is important to highlight the differences between these contracts.

In the first place, the concession delegates the execution of the public service to a private agent, without giving ownership of the property, contrary to privatization. In the second place, public-private partnerships (PPPs) are a type of concession contract, but they have different rules from those of common concession law regarding how the private agent's remuneration.

In general, PPP laws take different forms among countries, but usually this contractual model has a long-term¹¹. Finally, privatization refers to the sale of public assets to private enterprises, resulting in the control of private company over the property (e.g.: administration, investment and provision).

In this context, private sector participation may present an alternative solution for infrastructure financing, substituting the provision of fully public and private services, inducing the minimization of production costs by the private provider and of possible market failures that could occur under full privatization (CHONG et al., 2006). In this sense, in the traditional concession contracts all the risk lies with the private sector. PPPs, on the other hand, have an advantage where public and private sectors share the investment's risks given the high initial investment required and the uncertain long-term return. This contractual model allows to pool risks and to limit the liability of only one of the contracting parties, also sharing the benefits (NISAR, 2007).

As for the empirical evidence, Chong et al. (2006) estimates the impact of organizational choice on performance in the sanitation sector measured by consumer prices, controlling for supply and demand aspects that may affect prices. The authors find evidence that consumers pay more when municipalities choose PPPs. Wang et al. (2011) analyze the impact of the private sector on water supply in China and find evidence that private sector participation significantly improves water supply capacity, and that private international firms improve sector performance more than local private companies do.

Within this context, Yehoue et al. (2006) highlight the importance of governance and political stability issues on private investment in infrastructure. The authors investigate the determinants of public-private partnerships in emerging economies from 1990 to 2003, using a Zero Inflated Poisson (ZIP) model for the number of infrastructure projects for sectors such as energy, sanitation, transport and telecommunications. The study uses proxies aiming to investigate possible channels for budget constraint, market size, political environment, economic environment, and institutional quality. The results indicate that private investment prevails in economies with relatively large markets, high budget deficits and a stable political environment.

In the same line, Sharma (2012) studies the determinants of PPPs in developing countries from 1990 to 2008. Using a ZIP model, results show that macroeconomic stability, regulatory and governance quality and also market size are important for the private sector to engage in infrastructure projects.

Similarly, the study by Fernandez et al. (2015) sought to identify the determinants of investment and the number of public-private partnerships (PPPs) for developing countries in four sectors: water and sanitation, energy, telecommunications and transportation. Specifically for the water and sanitation sector, the important channels

¹¹ For more details of different projects of PPPs see Iossa and Saussier, (2018).

to determine the contracts were the political and legal systems, and macroeconomic environment. In a recent study, Pusok (2016) investigates how foreign private investment through public-private partnerships affects access to water and sanitation in developing countries. The results demonstrate the negative effects of corruption on the efficiency of private investments, given that when corruption is high in a country, private investors seek to maximize profit regardless of the demand for sanitation, which leads them to provide better quality water, but not adequate sanitation.

The studies of Prasad (2006), Frone (2013), Jiang et al. (2015) and Zeneli (2017) find evidence that private sector participation may have positive effects on infrastructure projects. In short, the literature provides evidence that private sector participation may be a good alternative in infrastructure investment improvements for developing countries, bringing innovation and technology to the water and sanitation sector. In the next section, we present the hypotheses of our study, in order to investigate the determinants of the numbers of contracts in the sanitation sector.

3. Empirical Hypotheses

In this section, we present the hypotheses that serve as the basis for our empirical model, in order to test which channels determine the number of contracts in the basic sanitation sector for developing countries. Addressing the issue of foreign investment, according to Wang et al. (2011), private international companies improve the performance of infrastructure investment relative to local companies, and most of the infrastructure projects are financed with foreign capital. Yehoue et al. (2006) argue that private investments tend to be more common in countries where governments suffer from heavy debt burdens. On the other hand, high external debt may mean that the country has a greater ability to raise external resources (such as the IMF), mitigating possible fiscal shocks, and there is no need to establish partnerships with the private sector for investments. Thus, we use two variables as proxies for foreign investment: (i) multilateral debt as a percentage of total external debt stock, loans and credits from the World Bank, regional development banks and other multilateral and intergovernmental agencies; and (ii) foreign direct investment as a percentage of Gross Domestic Product (GDP). Based on these arguments we present the first hypothesis:

Hypothesis 1: Foreign capital investments affect the number of projects in infrastructure.

A second important point is the demand for infrastructure in countries with fiscal restraint. Access to infrastructure services continues to be limited to a large share of the world's poorest populations (ESTACHE, 2006). Given this, we consider that countries with budget deficits and a larger population demand more infrastructure services and are more likely to collaborate with the private sector to fill gaps between supply and demand of public services. Therefore, we use population growth as a proxy for infrastructure demand. With this, we try to investigate the following hypothesis:

Hypothesis 2: Developing countries that are more populous demand more infrastructure services, which encourages the formation of partnerships with the private sector.

As for the country's macroeconomic environment, the degree of macroeconomic stability is important, because it could be used as an indicator which helps contracting parties to predict possible project contingencies (IOSSA and SAUSSIER, 2018). In general, infrastructure projects have high initial costs and the return on investment is of long term (YEHOUÉ et al., 2006). Thus, we use an indicator to test private attractiveness, being it the domestic credit to the private sector as a proportion of GDP. Considering these arguments, we intend to test the following hypothesis:

Hypothesis 3: Private investments in infrastructure are more likely in countries with a stable macroeconomic environment.

In addition to the macroeconomic environment, another aspect related to private investment is the business environment. In general, institutional quality such as corruption control and political stability are important factors for attracting private investment in developing countries, facilitating the business environment with the private sector (RESIDE, 2009). Compliance with contracts is another important factor for a country's credibility in attracting private companies. Legal institutions have a significant effect on private investment (PISTOR et al., 2000). Therefore, we test the conditions of the business environment including the degree of economic openness of the country. In this context, our hypothesis is as follows:

Hypotheses 4: A good business environment encourages private companies to get involved in infrastructure projects.

Weak political institutions increase the risk of corruption, reducing contract performance (IOSSA and SAUSSIER, 2018). Investments depend on political stability, centered on laws and regulations (JIANG, 2015). In this way, political instability and corruption affect the attractiveness and success of contracts with private companies, especially foreign ones. The country's high risk discourages investors from engaging in private partnerships (PISTOR et al., 2000). On the other hand, political instability may serve as an incentive for private investors seeking gains through corruption. In order to measure the effect of public sector governance, we use the World Bank's perception of corruption index. We should emphasize that this index does not measure corruption, but it identifies how this fact is perceived in each country, where it captures the perception of how public power is exercised for improper gains. This index ranges from -2.5 to 2.5, where the higher the less corrupt the country is¹². Therefore, we formulate the following hypothesis:

Hypothesis 5: Politically stable economies are more likely to attract investment through private capital.

In sum, the hypotheses are divided into five channels, taking into account the restrictions and incentives of public and private agents: foreign investment, demand for infrastructure, macroeconomic environment, business environment, and political environment. In the next section, we present the methodology used to test the five hypotheses.

4. Methodology

In this section, we present the data and our empirical strategy.

4.1 Data

We use data from the World Bank on private participation in infrastructure investments (PPI)¹³ for developing countries in the water and sewage sector. The PPI database provides information on the number of contracts for each of those investments from 2003 to 2016. Also, developing countries are classified as low and middle income based on per capita income and ability to borrow in market terms.

In this study, we analyze the determinants of the number of contracts in infrastructure, focusing on the basic sanitation sector, which consists of water distribution, sewage treatment and public cleaning. In addition to the PPI database, we use data on global development and governance indicators from the World Bank database.

The dependent variable (project number) was constructed from contract aggregation

¹² For more details see <http://databank.worldbank.org/>.

¹³ For more details see <http://databank.worldbank.org/>.

for each country each year in the specific water and sanitation sector according to the information made available on the PPI website. However, this variable has a high number of zeros, which occur for mainly two potential causes: (i) lack of demand for concession projects; (ii) the time of making a particular contract that may exceed one year.

Table 1 - Potential determinants of number of contracts in basic sanitation.

Determinants	Hypothesis	Variables	Subtitles	Data Source
Foreign Investment	Hypothesis 1: Foreign capital investments affect the number of infrastructure projects.	Multilateral debt (% of external debt)	multdebt	WDI ¹⁴
		Direct foreign investments (% of GDP)	invfor	WDI
Demand for infrastructure	Hypothesis 2: Developing countries that are more populous demand more infrastructure services, which encourages the formation of partnerships with the private sector.	Population Growth	pop_growth	WDI
Macroeconomic Environment	Hypothesis 3: Private investments in infrastructure are more likely in countries with a stable macroeconomic environment	Inflation measured by the PIB deflator	inf_gdp	WDI
		Domestic credit for the private sector (% GDP)	credit_p	
Business Environment	Hypothesis 4: A good business atmosphere encourages private companies to get involved in infrastructure projects.	Economic openness [(Exports + Imports) /GDP]	trade	WDI
Political Environment	Hypothesis 5: Politically stable economies are more likely to attract investment through private capital.	Corruption perception index	corrupt	Governance Indicators

Source: authors.

We have added year dummies to control possible economic shocks, such as the international crisis of 2008, which may have occurred in the period studied. We also added income (income, medium and low income) and region dummies, taking as base category the Latin America and the Caribbean region. Below we present the descriptive statistics of the variables used in our model.

Table 2 - Descriptive statistics.

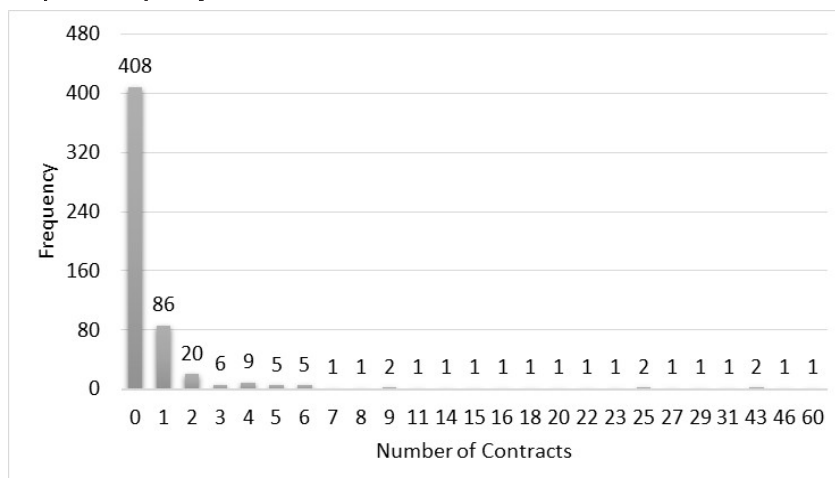
Variables	Observations	Mean	Standard Deviation	Minimum	Maximum
project numbers	560	1.31	5.30	0	60
foreign investment	560	4.28	4.91	-0.51	50.02
inflation_GDP	560	7.06	7.63	-29.69	80.75
multilateral debt	560	21.63	18.33	0.02	87.82
economic openness	553	77.08	36.06	19.10	210.37
population growth	560	1.34	1.17	-1.67	5.37
credit private	554	44.81	36.16	2.09	160.12
corruption index	560	-0.50	0.44	-1.72	0.79
dummy concession practices	560	5	11.03	0	65

Source: authors.

Next, we present the distribution of our dependent variable, the total number of contracts for the basic sanitation sector.

We can observe that there is an excessive number of zeros in our dependent variable. There are 408 observations where no new contract was signed in a given year in a country out of 560 observations. Next, we present how we constructed our control variable for the excess of zeros.

¹⁴ The acronym WDI is stands for World Development Indicators.

Graph 1 - Frequency distribution for the number of contracts.

Source: authors.

4.1.1 Control Variable for the Excessive Number of Zeros

When performing the regression with inflated models of zeros it is necessary to use a control variable for the excessive number of zeros of the sample. Since, when a country does not have the contract information in a given year, the dependent variable takes on zero value. In view of this, the excessive number of zeros can be explained by the fact that the concession contracts are long-term and, therefore, in the year in which the country does not have contract information in our sample, it may mean that it is complying with a current contract or renegotiating (MORAES and TAGLE, 2017). It is worth highlighting how many contracts of the database are in relation to the year in which it was signed.

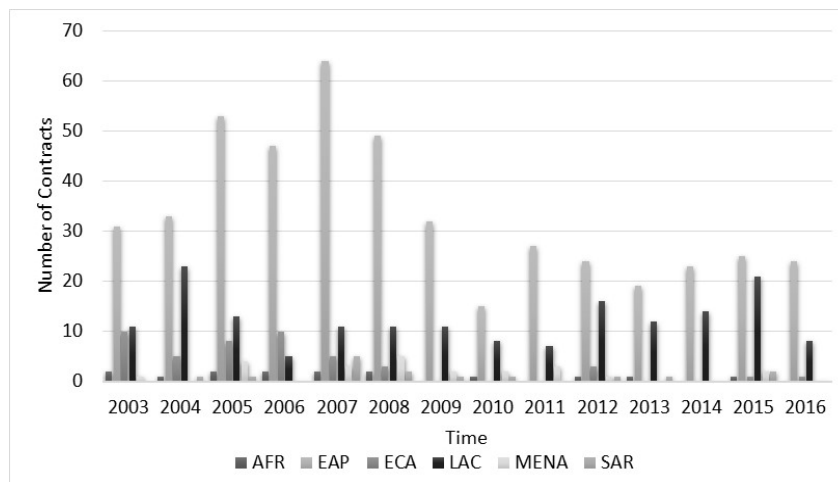
Thus, based on the instrument used by Acemoglu et al. (2014), in which regional waves of democratization influence other countries to democratize, and may occur due to regional economic trends, causing a spillover effect (overflow). Thus, after the first democratization in a region, the participation of the countries that democratize in that region converges swiftly to other regions, which would be the waves of democratization. In this context, our hypothesis is that developing countries, from the same region, tend to follow concession practices in neighboring countries in order to leverage infrastructure investments, influencing the implementation of partnerships with the private sector, in order to fill the gap between fiscal restraint and demand for infrastructure.

In this way, we constructed a variable based on the number of contracts from neighboring countries in relation to the previous year for each country in our sample. Thus, to control the excessive number of zeros, we use a dummy variable that takes on the value of 1 when the neighboring country has a contract in the previous year, and 0 otherwise.

In addition, in order not to lose one year of the sample in the construction of the variable, we used the year 2002 that had information of contracts of the neighboring countries in the base of the PPI. Besides, in order not to lose a year of the sample in the construction of the variable, we used the year 2002 which possessed information of the contracts of the neighboring countries in the database of the PPI.

The following graphs show the number of contracts by region over the analyzed period and the percentage of the total number of contracts for each region¹⁵.

¹⁵ The list of countries by region is given in tabel 1 of the appendix.

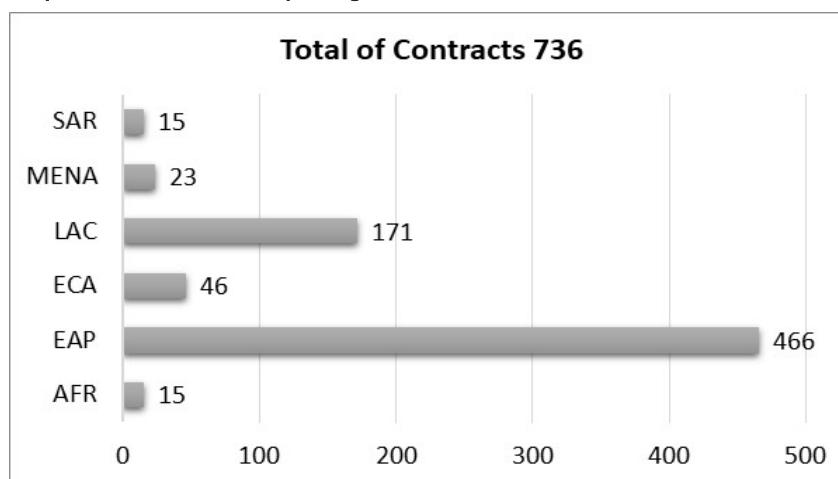
Graph 2 - Number of Contracts per Region.

Source: authors.

Note: Regions are described as: Africa - AFR; East Asia and the Pacific - EAP; Europe and Central Asia - ECA; Latin America and the Caribbean - LAC; Middle East and North Africa - MENA and South Asia - SA.

Obs: Classification of regions by the World Bank.

It can be observed that the East Asia and Pacific region holds the largest number of contracts in basic sanitation over the years, followed by Latin America and the Caribbean. We noticed a growth in the number of contracts in 2003 and a fall from 2007, which may have occurred due to the international crisis of 2008, affecting other regions as well, which can be explained by the fact that most of the investments in infrastructure are provided through foreign capital. In the next graph we describe the percentage of contracts by region in relation to the total contracts of the sector.

Graph 3 - Total of Contracts per Region.

Source: authors.

Note: Regions are described as: Africa - AFR; East Asia and the Pacific - EAP; Europe and Central Asia - ECA; Latin America and the Caribbean - LAC; Middle East and North Africa - MENA and South Asia - SA.

Obs: Classification of regions by the World Bank.

In Graph 2 we present the percentage that each region holds of the total of analyzed contracts of the sector. The East Asia and Pacific region accounts for more than 50% of total contracts, with 58% of the region's 64% being contracts from China and 14% from 23% of the Latin American and Caribbean region belong to Brazil, characterizing these countries as the outliers of our sample. The next subsection describes the empirical strategy used in the estimates of this study.

4.2 Empirical Strategy

As an empirical strategy to perform the data estimates and to find the potential determinants of the number of contracts in infrastructure projects for the basic sanitation sector, we use counting estimators in the panel data structure¹⁶. According to Wooldridge (2010), since the reason for a country's lack of data is not correlated with idiosyncratic errors, the unbalanced panel will not cause problems. Thus, in the absence of any observations, the panel used will be characterized as unbalanced.

Our model has a discrete count dependent variable, with the total number of contracts in water and sanitation. The default model for counting data is Poisson regression. However, because our data are overdispersion, with the variance greater than the mean in the dependent variable, the traditional Poisson regression model may have biased estimated parameters. In this perspective, we performed tests to evaluate the best adequacy between models with zero inflation.

As we can analyze in Table 3, the variance of the variable dependent on the number of contracts is higher than its mean, representing a strong indication of the existence of overdispersion in the data.

Table 3 - Mean and variance of dependent variable.

Variable	Mean	Variance
number of project	1.31	28.10

Source: authors.

In addition, according to Cameron and Trivedi (2010), a formal test of the null hypothesis of overdispersion can be based on the following equation:

$$Var(y|x) = E(y|x) + a^2 E(y|x) \quad (1)$$

With the variance function for the Negative Binomial model, the test can be implemented by an auxiliary regression of the dependent variable, $\{(y - \hat{\mu})^2 - y\} / \hat{\mu}$. About $\hat{\mu}$, without the intercept term, performing a t-test to know if the coefficient of $\hat{\mu}$ is zero.

Table 4 - Test of overdispersion.

	Coef.	St.Err.	t-value	p-value	[95% Conf Interval]	
muhat2	29.685	8.331	3.56	0.000***	13.319	46.050
Constant	47.761	12.601	3.79	0.000***	23.009	72.513

Source: authors.

¹⁶ To perform the estimations the Stata 14 software was used.

The result indicates the presence of significant overdispersion, and while inflated models of zeros are more appropriate with excessive amounts of zeros in the dependent variable, they are even more recommended when overdispersion in the data.

Thus, to solve the problem of the occurrence of many zeros, we used the inflated regression models of zeros, introduced by Lambert (1992). When we analyze the likelihood ratio test, for the comparison between the models, Zero Inflated Negative

Binominal (ZINB) presents a higher value compared to Zeros Inflated Poisson (ZIP), according to the following table.

Table 5 - Log likelihood test.

	ZIP	ZINB
Log Likelihood	-691.39	-545.04
Likelihood test of φ	1.24 (0.41)	$\chi^2 = 292.70$, $\Pr \geq \chi^2 = 0.0000$

Source: authors.

We observed from the outputs that the value obtained from the logarithm of the likelihood function is considerably higher for the ZINB model, presenting an indication of better adequacy over the ZIP model for our data set.

In addition, the parameter φ , which is the inverse of the gamma parameter, is statistically different from zero and with an estimated value of 1.24. For the likelihood ratio test for the φ parameter, we can conclude that the null hypothesis that the parameter is statistically equal to zero can be rejected at the significance level of 5% ($\chi^2=0.000<0.05$), proving the existence of overdispersion in the data.

Furthermore, we can observe the differences in the comparison of the observed and predicted mean of the models in Table 4.

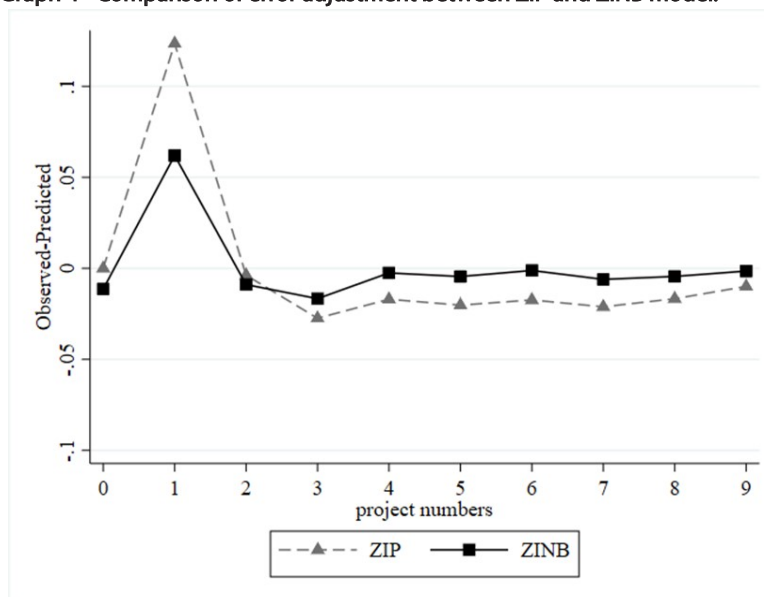
Table 6 - Comparison of mean observed and predicted count.

Model	Maximum Difference	At Value	Mean Diff
ZIP	0.124	1	0.026
ZINB	0.062	1	0.012

Source: authors.

The maximum mean difference between the observed and predicted probabilities for the ZIP model is 0.026 and 0.012 for ZINB. Graph 1 allows comparative analysis between the error terms generated in the two models, where the ZINB has the closest curve to zero.

Graph 4 - Comparison of error adjustment between ZIP and ZINB model.



Source: authors.

While the inflated Poisson model of zeros is estimated from the combination of a Bernoulli distribution with a Poisson distribution, the inflated Negative Binomial zeros model is estimated by combining a Bernoulli distribution with a Poisson-Gamma distribution. Thus, one way to model counting data with overdispersion is to use the Binomial negative model. We follow Lambert (1992) and for Zero Inflated Negative Binomial model we have the following.

$$P(Y_{it} = y_{it}) = \begin{cases} p_{it} + (1 - p_{it}) \cdot \left(\frac{1}{1 + \phi \lambda_{it}} \right)^{1/\phi}, & y = 0 \\ (1 - p_{it}) \cdot \left(\frac{y_{it} + \phi^{-1} - 1}{\phi^{-1} - 1} \right) \cdot \left(\frac{\phi \lambda_{it}}{1 + \phi \lambda_{it}} \right)^{y_{it}} \cdot \left(\frac{1}{1 + \phi \lambda_{it}} \right), & y > 0 \end{cases} \quad (2)$$

where y_{it} is the number of contracts in basic sanitation ($y \geq 0$), with a variation unit of ($i=1, \dots, 40$), that is, the countries, and t indexes the time unit ($t=2003, \dots, t=2016$), ϕ represents the inverse of the parameter that determined the Gamma distribution, λ is the average parameter, p is the proportion of zeros, in which a probability exists, p , of the observation take on a value different to zero, that is $p(y_{it} \neq 0)$ and the possibility of the observation take on the zero value, $p(y_{it}=0)$, where:

$$p_{\logit_{it}} = \frac{1}{1 + \exp(\gamma + \delta W_{it})} \quad (3)$$

where W is the inflated variable that explains the zeros. In our model we used the control variable for concessions in neighboring countries for the idea of overflow effect: Finally, λ_{it} is defined as:

$$\lambda_{it} = \exp(\alpha + \beta_1 X_{1t} + \dots + \beta_k X_{kt}) \quad (4)$$

where X_{kt} represents the potential determinants of the number of contracts for basic sanitation discussed previously.

Based on (1) and from the likelihood logarithm of the function (log likelihood) we can estimate $\phi, \alpha, \beta_1, \dots, \beta_k, \gamma, \delta$ of the Zero Inflation Negative Binomial Model (ZINB), and we have:

$$LL = \sum_{y_{it}=0} \ln \left[p_{it} + (1 - p_{it}) \cdot \left(\frac{1}{1 + \phi \lambda_{it}} \right)^{1/\phi} \right] + \sum_{y_{it}>0} \left[\ln(1 - p_{it}) + Y_{it} \cdot \ln \left(\frac{\phi \lambda_{it}}{1 + \phi \lambda_{it}} \right) - \frac{\ln(1 + \phi \lambda_{it})}{\phi} \right] c + \ln \Gamma(Y_{it} + \phi^{-1}) - \ln \Gamma(Y_{it} + 1) - \ln \Gamma(\phi^{-1}) = \max \quad (5)$$

For the purpose of robustness analysis, we used the regression models of Negative Binomial, Poisson and Poisson inflated zeros. According to Hausman's test, all models were estimated with fixed effect. In order to control heteroscedasticity, we used robust standard errors in all estimates. Thus, in order to capture the determinants of the number of private infrastructure investment contracts, we test as a dependent variable, the total number of projects, which account for the occurrence of private partnership agreements in the water and sanitation sector. In the next section we present the empirical results of the estimates made with the specified dependent variable.

5. Empirical Results

In this section, we discuss the empirical results with the Zero Inflation Negative Binomial model. For the purpose of robustness analysis, we used the regression models of Negative Binomial, Poisson and Poisson inflated zeros. According to Hausman's test,

all models were estimated with fixed effect. We emphasize that all models present the same number of observations and the same variables of interest.

In order to calculate the marginal effect, we used the method proposed by Beaujean and Morgan (2016), applying the following formula: $100 \times [\exp(\text{estimated coefficient} \times \Delta) - 1]$, where Δ is a change of a unit, $\Delta = 1$.

5.1 Negative Zero Inflated Binomial Model

In Table 7 we present the results for the Negative Binomial Inflated by Zeros model - ZINB. We conducted the likelihood ratio test, which compared the estimated model with zero inflation of the ZINB and ZIP model and defines which is best suited for our data set. Each column in Table 3 presents a different specification, in order to capture the fixed effect of the temporal dummy, income dummy and region dummy, which has the Latin America and the Caribbean as base category.

For the ZINB regression, it is necessary to use a variable that controls for the excessive number of zeros. We use a dummy variable (conc) based on the idea that the influence of concession practices of neighboring countries (that share frontiers) generates an overflow effect, which indicates the probability of the existence of private investments in the country. Our control variable is statistically significant in all models with inflation of zeros.

Table 7 - Results for the Negative Inflation Zero Binomial Model.

Dependent variable: number of contracts	ZINB (1)	ZINB (2)	ZINB (3)	ZINB (4)
multilateral debt	-0.03*** (0.01)	-0.04*** (0.01)	-0.03*** (0.01)	-0.03*** (0.01)
foreign investment	-0.01 (0.03)	0.02 (0.03)	-0.00 (0.03)	0.05* (0.03)
population growth	-0.23** (0.10)	-0.09 (0.09)	-0.20* (0.11)	-0.32 (0.22)
inflation_GDP	-0.00 (0.02)	-0.03* (0.01)	-0.00 (0.02)	0.00 (0.01)
credit private	0.02*** (0.00)	0.03*** (0.00)	0.02*** (0.00)	0.00 (0.00)
economic openness	-0.02*** (0.00)	-0.03*** (0.00)	-0.02*** (0.00)	-0.03*** (0.00)
corruption index	0.32 (0.28)	0.11 (0.23)	-0.11 (0.28)	0.69** (0.33)
temporal dummies	no	yes	no	no
dummy renda			-0.92*** (0.19)	
dummy africa				-0.82* (0.42)
dummy east asia and the pacific				2.04*** (0.43)
dummy europe and central asia				-0.55 (0.58)
dummy middle east and north africa				-0.00 (0.40)
dummy south asia				-0.22 (0.39)
dummy concession practices	-1.48** (0.60)	-1.80* (0.98)	-1.21*** (0.40)	-12.42*** (1.93)
likelihood-ratio test φ	$\varphi = 1.24$ (0.41)		$\chi^2 = 292.70$	$\Pr \geq \chi^2 = .0000$
N° Observations	547	547	547	547

Source: authors.

Notes: Robust Standard errors between parentheses * significant at 10% ** significant at 5% and significant *** at 1%. Obs.: Classification of the regions from the World Bank.

Our results show that the multilateral debt (*multdebt*) as a percentage of the external debt stock has a negative impact on all models with zero inflation (ZINB), which means that on average an increase of 1% in multilateral debt would lead to a 3.92% reduction in the number of contracts. This indicates that the fulfillment of the commitments with the country creditors is an important factor to explain the growth of the number of contracts. On the other hand, external indebtedness may soften the restraint of financial resources for infrastructure investments and, alternatively, could mean that government authorities may capture external resources more easily. Results also indicate a 1% increase in direct foreign investment as a percentage of GDP generates an increase of 5.13% in the number of contracts, allowing the formation of new contracts and reinforcing the hypothesis that investments through foreign capital influence the number of contracts.

As for demand for infrastructure, we see a negative impact, in which a 1% increase in population growth (*pop_growth*) reduces demand for projects by approximately 20.55%. In the macroeconomic environment, inflation (*inf_gdp*) has a negative impact, in which the 1% increase leads to a reduction of 2.96% in the number of contracts. On the other hand, the domestic credit to the private sector (*credit_p*) has a positive effect on all estimates, except when we include a region dummy, where a 1% increase in private credit generates an increase of 3.05% in the number of contracts. This indicated that the incentives for private capital inflows into the economy are an important factor in the formulation of contracts for the water and sanitation sector. In this way, developing countries with stable macroeconomic conditions are more likely to attract private capital to leverage the number of infrastructure contracts in the sector, since the initial investment is high and the return is long term.

As for the business environment, we can see that the economic openness (*trade*) has a negative impact on all models, in which a 1% increase in economic openness reduces the number of contracts by 2.96%. In relation to the corruption index (*corrupt*), results indicate that countries with political stability motivate investors to engage in infrastructure projects. It should be noted that the corruption index is a perception of how the country is viewed internationally by other nations, capturing how public power is exercised for private gain.

Our income dummy is statistically significant and negative, that is, the fact that the nation is middle-income within the set of emerging countries entails a reduction of approximately 60% in the number of contracts. The region of Africa has a negative effect of approximately 55%, possibly because this region is less developed economically relative to the Latin America and the Caribbean region. The positive result for the East Asia and Pacific region may be explained by the presence of China, which holds more than 50% of the contracts of our sample.

We highlight the results of our control variable for the excessive number of zeros, assuming that developing countries, in the same region, tend to follow concession practices in neighboring countries, in which there is a spillover effect. We emphasize that the coefficient of the inflated variable explains the probability of always have zero contracts. In the dummy income model, the fact that neighboring countries have contracts in basic sanitation reduces in approximately 70% the probability of countries that share frontiers not having contracts in the sector indicating an overflow effect. In other words, the fact that countries that share frontiers with Brazil, for instance, have concession practices, reduces the country's probability of not having contracts in the sanitation sector. In this way, the foreign investment, the macroeconomic condition and the political stability are important channels for the formulation of contracts for the water and sanitation sector.

5.2 Robustness

Robustness Analysis of the Total Number of Contracts with the Negative Binomial Models, Poisson and Zero Inflated Poisson (ZIP).

Compared to the results obtained with the Zero Inflation model (ZINB), the signals of the coefficients of the variables of domestic credit to the private sector (*credit_p*) and economic openness (*trade*) in the Negative Binomial and Poisson models are opposite. The demand for infrastructure, with population growth (*pop_growth*), maintains the negative and significant effect in relation to the number of contracts. We also observed that the variables of the foreign investment channel (*multidebt*) and (*invfor*) and the political environment channel (*corrupt*) do not present statistical significance for the formulation of new contracts.

Regarding the ZIP model, the variables are statistically significant as well as in the ZINB model, with small differences. However, as shown in the empirical strategy section, the ZINB model is best suited to our data set in all tests performed.

The fact of the difference between the estimates is possibly caused by the presence of overdispersion, due to the excess of zeros since we are not controlling the excess of zeros of the dependent variable in the models of Negative Binomial and Poisson.

Table 8 - Results for the Negative Inflation Zero Binomial Model.

Dependent variable: number of projects	Binomial Negative	Binomial Negative	Poisson	Poisson	ZIP	ZIP
multilateral debt	0.02 (0.01)	-0.00 (0.02)	0.02 (0.01)	0.00 (0.02)	-0.02*** (0.01)	-0.05*** (0.01)
foreign investment	0.01 (0.04)	0.01 (0.04)	0.02 (0.04)	0.03 (0.05)	0.16*** (0.04)	0.20*** (0.06)
population growth	-1.20*** (0.34)	-1.07*** (0.34)	-1.10** (0.53)	-1.06** (0.50)	-0.01 (0.10)	0.08 (0.12)
inflation_GDP	0.02 (0.01)	0.02 (0.02)	0.01 (0.01)	0.03* (0.01)	0.01 (0.02)	-0.03 (0.02)
credit private	-0.01** (0.01)	-0.00 (0.01)	-0.01* (0.01)	-0.01 (0.01)	0.02*** (0.00)	0.02*** (0.00)
economic openness	0.02*** (0.01)	0.01* (0.01)	0.02** (0.01)	0.01 (0.01)	-0.02*** (0.00)	-0.03*** (0.00)
corruption index	0.58 (0.46)	0.41 (0.48)	0.42 (0.65)	0.45 (0.51)	-0.91** (0.41)	-0.92** (0.38)
dummy concession practices	-	-	-	-	-0.88*** (0.22)	-0.98*** (0.27)
temporary dummies	no	yes	no	yes	no	yes
Nº Observations	547	547	547	547	547	547

Source: authors.

Notes: The result tables display Binomial Negative, Poisson and Zero Inflated Poisson (ZIP) side by side for comparison purposes. Robust Standard errors between parentheses
* significant at 10% ** significant at 5% and significant *** at 1%.

Our results are aligned with Yehoue et al. (2006), this presents evidence that the channels of budgetary restraint, macroeconomic environment, rule of law and demand for infrastructure are determinant for private investment. In this study, we observed that foreign direct investment and political stability also stand out as important channels for increasing the number of contracts in the basic sanitation sector.

In the study of Sharma (2012), political stability and market size are important determinants of infrastructure projects. Differently, in our analysis, we report that the foreign investment channel and a stable macroeconomic environment stand out as channels for the number of contracts in the sector, given that most investments are financed with foreign capital and a sound macroeconomic environment is important to reduce uncertainties for the private companies.

Overall, our estimates are in agreement with previous studies. However, our results suggest that the foreign investment channel is an important determinant of the increase in the number of contracts in basic sanitation sector.

In the models used for the robustness analysis, even if some coefficients were kept with the same signals of the zero inflation model, other coefficients presented opposite signs, which may be due to the fact that we are not controlling the excessive number of zeros, reinforcing the results found in the ZINB model. In this way, the Zero Inflation Negative Binomial model presents more robust and consistent results, justifying the significance of the control variable used for zero inflation.

In short, a stable macroeconomic environment, investment through foreign capital and political stability contribute to the increase in the number of contracts in the basic sanitation sector. We emphasize that our control variable for the excessive number of zeros has a strong overflow effect in all the estimated models, in which it reduces the probability that neighboring countries (that share borders) do not have contracts in the water and sanitation sector

6. Final considerations

Access to basic sanitation is crucial for the sustainable development of countries, not only from a social perspective but also from an economic one. Inefficiency in the infrastructure sector has a direct impact on public health, which ultimately affects the productivity and overall economic growth of a country. To address this issue and meet growing demands, the participation of private investors in infrastructure projects has been widely discussed among governmental authorities. The reason being, that changes in the relationship between the public and private sectors can lead to greater efficiency in the provision of services and ultimately increase social welfare.

This study, based on the works of Yehoue et al. (2006) and Sharma (2012), analyzed the determinants of the number of contracts for the basic sanitation sector in developing countries, from 2003 to 2016. It particularly considered the effect of foreign investment and added a specific variable to control for the excessive number of zeros in the dependent variable. The zero control variable is based on the premise that the concessionary practices of countries in the same region, that is, that have common borders, generate a spillover effect for neighboring countries to adhere to this arrangement. The results show a strong overflow effect in all the estimated models, which reduces the probability of neighboring countries not having contracts in the water and sanitation sector.

From an economic perspective, political stability and a stable macroeconomic environment are fundamental to attract foreign investment and promote a good business environment for private enterprises. These factors are crucial to reduce uncertainty in the choice of private companies for infrastructure projects, which ultimately leads to an increase in the number of contracts in the basic sanitation sector. This increase of contracts in the basic sanitation sector directly relates to the economic growth and development of a country as it has a direct impact on public health and the quality of life of individuals, which are important factors in economic growth.

In conclusion, partnerships between the public and private sectors, through concession contracts, can be an effective tool for policymakers to address bottlenecks in the basic sanitation sector, meet growing demands, and bring innovation and technology to the sector. This, in turn, can improve public health, boost productivity, and promote sustainable economic growth.

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Appendix

Table A1 - Countries by region for the water and sanitation sector of the ppi base.

AFR	EAP	ECA	LAC	MENA	SA
	China	Albania	Argentina	Algeria	India
South Africa	Philippines	Armenia	Brazil	Egypt	Nepal
Cameroons	Indonesia	Georgia	Colombia	Jordania	
Ivory Coast	Malaysia	Republic of	Ecuador	Morocco	
Ghana	Thailand	Kyrgyzstan	Guatemala	Tunisia	
Mauritius	Vietnam	Romania	Haiti		
Mozambique		Russia	Mexico		
Congo Republic		Serbia	Panama		
Senegal		Ukraine	Peru		
Sudan					
Tanzania					

Source: authors.

Note: The regions are described as: Africa - AFR; East Asia and the Pacific - EAP; Europe and Central Asia - ECA; Latin America and the Caribbean - LAC; Middle East and North Africa - MENA and South Asia – SA, according to the World Bank classification.

Table A2 - Correlation matrix.

	contracts projects	foreign investment	inflation GDP	multilateral debt	economic openness	population growth	credit private	corruption index
contracts projects	1.0000							
foreign investment	-0.0412	1.0000						
inflation GDP	-0.0399	-0.0669	1.0000					
multilateral debt	-0.1687	-0.0046	0.0452	1.0000				
Economic openness	-0.1554	0.3742	-0.1415	-0.1558	1.0000			
population growth	-0.1235	0.0630	-0.0182	0.1830	0.0063	1.0000		
credit private	0.2985	-0.0392	-0.1960	-0.3337	0.3636	-0.2220	1.0000	
corruption index	0.0409	0.0243	-0.1381	-0.1465	0.1738	-0.1790	0.5058	1.0000

Source: authors.

Note: For the construction of this table 547 observations were used.