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Deciding on Financial Renegotiation in Public-Private Partnership Projects

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Abstract. This paper analyzes the renegotiation problem in the context of public-private partnership projects. Utilizing a game-theoretic approach, an equilibrium is found in which the government finds that accepting renegotiation can be efficient. A first indicator is proposed based on the public sector comparator (PSC) that can be estimated by policymakers as an additional tool when deciding about renegotiation. A second more theoretical indicator is derived to analyze the economic and financial variables affecting renegotiation. This indicator is applied to four case studies in different countries (England, Taiwan, Portugal and China) and the results suggest that the model performs well.

Keywords. Public-Private Partnership, Renegotiation, Value for Money, Game Theory

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1. Introduction

In the last two decades, public-private partnership (PPP) projects are a growing research topic as asserted by Cui et al. (2018). The authors indicate some research gaps and research directions, one of which would be to explore and improve the efficiency of contract negotiation and renegotiation in the context of achieving flexible contracts. They remark that although the concept of 'flexible contracts' and 'renegotiation' introduce various alternative methodologies or guidelines, they are still at a nascent stage and offer enormous scope for refinement. In fact, Cruz et al. (2014) highlight that renegotiations are clearly one of the most critical issues affecting the performance of concessions.

The present work focuses on financial renegotiations involving PPP projects, in particular, as it uses a game-theoretic framework to develop tools that assist in renegotiation decisions by relying on certain conditions to generate a practical method that can be applied to cases in the real world.

The article is organized as follows. In the next section, the literature about renegotiation in PPP is reviewed. In section three, the main causes of renegotiation are identified. In section four, a renegotiation game framework is explained. In section five, two methods are introduced

that identify whether to reject or accept a renegotiation proposal. Section six analyzes four real case studies of PPP renegotiation. Finally, section seven draws some conclusions.

2. Literature review

A recent review of the PPP literature by Cui et al. (2018) identified six potential research topics: financial packages and PPP application (G1), economic viability and value for money (VfM) (G2), risk management and success factors (G3), procurement and contract management (G4), performance management (G5), and governance and regulation (G6). Renegotiation appears as an important topic in the procurement and contract management (G4) group.

Ho (2009) argues that financial renegotiation plays a critical role in the success of a PPP project. Financial renegotiation refers to revising financial subsidy measures after a PPP contract has been executed, when conditions have changed unfavorably and significantly. Nikolaidis and Roumboutsos (2013) describe the process of renegotiation in PPP projects as a bargaining process in which the parties seek to reach an agreement on one particular option from a set of available alternatives. Ho (2006) contends that the fact that the government may bail out a distressed project and renegotiate with the developer in PPP projects can lead to serious opportunism problems in project administration. Engel et al. (2014) posit that governments should limit contract renegotiations because they can erase the efficiency gains associated with PPPs. Hasselgren et al. (2014) point out that sometimes objective reasons arise that make renegotiation necessary, even in contracts that initially seemed to consider all possible contingencies. This is related to the paradigm of incomplete contracts established by Grossman and Hart (1986), Hart and Moore (1990), and Hart (1995).

Bitran et al. (2013) assert that contract renegotiations typically mean high fiscal costs and more onerous contractual terms. Guasch et al. (2014) reported that a significant number of PPP projects have been renegotiated shortly after the contracts have been signed. These renegotiations frequently occur a short period of time after – and sometimes even before – the financial terms have closed. The authors claim that 68% of PPP projects are renegotiated and that the average time before renegotiation is 1 year after execution. In sectors such as transport or water, this problem is even more evident, with percentages of 78% and 87% and an average time of 0.9 and 0.8 years before renegotiation, respectively.

The empirical evidence on PPP renegotiations at an international level is diverse. Gifford et al. (2014) argue that United States (US) PPP renegotiations have not experienced the same level of analysis as those in international markets, which might be explained by the relatively few US PPPs and scarce data availability. Infrastructure-oriented PPPs in the US constitute a relatively new market that is still growing. The authors posit that there is not enough evidence regarding the causes of renegotiations in US PPPs. Baeza and Vasallo (2010) note that Spain has a long history of partnering with the private sector to help build and operate public infrastructure and that its PPP contracts suffer from significant income overestimation and are

subject to frequent renegotiations. Cruz and Marques (2013) examine Portugal (the European country with the most PPP projects) and identify specific variables that explain why PPPs are so likely to be renegotiated in Portugal – the average renegotiation rates are 67% and 100% in the water and transportation sectors, respectively – such as the magnitude of concessions and the dearth of regulations governing the executed contracts. Guasch et al. (2014) analyze the renegotiation experience in Latin America and find a renegotiation rate of 61%. Chang (2013) asserts that compared with the developed countries, China is a latecomer to the practice of engaging in PPPs.

Historically, the private sector was strictly forbidden to take part in the construction and operation of public infrastructure. Hasselgren et al. (2014) point out that after several years and hundreds of PPP projects, there have been no renegotiations in India. To avoid moral hazards in the bidding process, it was established that renegotiation is only allowed for exceptional cases. Renegotiation can be initiated by the government, the developer or by both parties. The government tends to renegotiate when there are changes to the ruling party, changes in priorities or because it cannot fulfill its contractual obligations. Conversely, the private sector can initiate renegotiation for opportunistic reasons and in seeking to maximize the net present value (NPV) of the PPP contract. Guasch et al. (2014) found that 61% of renegotiations are initiated by the developer.

Hart and Moore (1988) and Dewatripont (1988) discuss the essence of renegotiation and its impacts. There are certain models of renegotiations, such as Maskin and Moore (1999), Segal (1999), Anderlini and Felli (2001), Ishiguro and Itoh (2001) and Tiong and Alum (1997). The present paper relies on Ho (2006) and develops an indicator when a government encounters the decision to rescue (or not rescue) a distressed project and what the impact is in terms of VfM. Developing useful tools for policy makers facing the dilemma of whether to renegotiate a PPP is important for several reasons: 1) if a request for renegotiation is always granted, the developers would then be incentivized to bid optimistically to win projects that will likely be renegotiated and 2) if renegotiation is expected, the agent may choose inefficient actions that reduce overall or social efficiency but increase the agent's payoff.

3. Causes of renegotiation

Before analyzing the causes of renegotiation, it is important to distinguish the different types of PPP depending on the bundling and the compromises of the private sector. The Build-Operate-Transfer (BOT) model implies that the private sector builds, operates, and transfers the asset to the public sector at the end of the period; DBOT means that the private sector designs (D), builds (B), operates (O) and transfers (T) the asset; the DBFOT model includes assistance in financing (F) a project. There are variations of these models depending on the bundling. For instance, the DBFOM includes maintaining (M) the infrastructure but there is no transfer; this model is also called Private Finance Initiative (PFI) arrangements in the United Kingdom (UK).

Actually, as asserted by Makovšek and Veryard (2016), the typical PPP contract is a DBFOM type, where the private partner designs, builds, finances and operates the asset. The present work will focus on this model including private financing. Iossa and Martimort (2012, 2015) indicate that the financier can benefit the project by providing information and experience. In this sense, external finances would alleviate the moral risk of the contract both in the construction and operation stages, thus improving the risk allocation. Note that DBFOM is the model that includes more services, increasing the probability of renegotiation at some stage.

Tirole (1999) analyzes renegotiations in terms of transaction costs, explaining that renegotiation occurs because the cost of writing complete contracts can be high. In addition to contractual incompleteness, Marques and Berg (2010) consider that imperfect allocation of risk is an important factor in renegotiations. Fatokun et al. (2015) identify the following main factors involved in renegotiations of PPP contracts for road construction: the lack of an adequate contract design; frequent opportunistic behavior by both the public and private partners during implementation of PPPs; material changes in those conditions affecting revenue and costs that are beyond the reasonable assumptions in the original contract; corruption; and political and economic instability, which typically acts to reduce the chances of the public partner achieving its objective of VfM. Fatokun et al. (2015) posit that the driving factors behind PPP contract renegotiations in Spain include faulty contract design, defective regulations, over-estimation of traffic, inflexible contracts, changing construction risks and inadequate strategic network planning, among others.

Hasselgren et al. (2014) classify the different reasons why renegotiations might arise into the following four categories that are presented in Table 1: The first category is technocratic and endogenous factors, which is related to the business and management aspects of PPP contracts. The second category is technocratic and exogenous factors, which can result in PPPs failing to meet their performance goals, generally due to the macroeconomic environment. The third category is subjective and endogenous factors, which is related to imperfect and asymmetrical information. In this regard, the private sector may bid aggressively with the expectation to renegotiate after winning. The public sector can be affected by selection bias, which tends to choose bids that promise more than can realistically be delivered. It can result in the so-called "winner's curse," where the bidder tends to bid below the actual cost, since he believes that this is the only way to win. In fact, Ho (2006) contends that opportunistic bidding behavior in PPPs indicates that bidders' proposals intentionally understate the possible risks involved or overstate project profitability to win contracts from their competitors. Athias and Nuñez (2008) found evidence of a strong winner's curse effect when the public agency has limited experience with PPPs. Cruz and Marques (2013) also conclude that the correlation in Portuguese PPPs between the type of award and ex post renegotiation supports both the winner's curse and the strategic underbidding theories.

Finally, the fourth category is subjective and exogenous reasons, which involve the behavior of the government and public sector. In democratic countries, the governors have a term of four or five years. This can generate a tendency to think in the short term and lose the long-term

perspective. When this happens, politicians can commit to PPP projects that they know will be renegotiated in the future when they are no longer in government. There is a severe risk of using PPPs to elude budgetary spending restrictions, transferring the fiscal burden to the next government. Principal-agent characteristics might also be particularly difficult to incorporate into public sector settings. The actors involved (for example, the legislature, individual politicians, the executive and its agencies) might relate to one another in many different ways in aiming to achieve a wide spectrum of objectives, sometimes consistent – and sometimes inconsistent – with one another. Bi and Wang (2011) recognize that current scholarship focused on moral hazard in PPP renegotiations is limited.

Table 1. Causes of renegotiation - Four different categories

Endogenous Factors	
1) Objective (Technocratic)	3) Subjective (Political)
Management performance and coordination, construction risk, supply contract risk.	Winner’s curse, opportunism, strategic misrepresentation.
Organization theory, Engineering	Contract/game theory, Transaction cost theory
Exogenous Factors	
2) Objective (Technocratic)	4) Subjective (Political)
Economic downturn, Changes in demand patterns, Changes in institutional environment.	Public sector opportunism, Principal-agent problems.
Institutional theory, Neoclassical theory	Public choice theory, Political science

Source: Own elaboration based on Hasselgren et al. (2014)

According to Hasselgren et al. (2014), if the risks were properly allocated, the endogenous factors do not justify renegotiation of the contract, since they must be assumed by the corresponding parties (public or private). Only exogenous reasons and in extreme cases is the renegotiation mechanism enabled. An example of this could be the imminent bankruptcy of the country. Cruz and Marques (2013) assert that having a strong regulatory body may diminish the rate of renegotiations.

4. Renegotiation game framework

The present work is based on the game-theoretic framework developed by Ho (2006), who investigates when and how the government rescues a distressed project. In this sense, the model focuses on financial renegotiation involved in revisiting financial subsidy negotiations after a contract was executed, particularly when conditions have changed unfavorably and

significantly. The present paper introduces benefit functions for the two players – the developer and the government – allowing an analysis of the conditions that favor the renegotiation of a contract for purposes of obtaining an indicator of the efficiency of renegotiating a contract.

Figure 1 presents the dynamic game in extended form. It is a two-stage game with two players (developer and government). The game begins from adverse situations in which the developer has two strategies: 1) they can declare the project bankrupt and the game is over; or 2) the developer can attempt to ask the government to rescue and subsidize at a percentage of the initial investment and the cost flow (g). This second strategy implies that the developer must negotiate with the government. If the developer chooses to negotiate, the government has two strategies: 1) to reject renegotiation (letting the developer go bankrupt and retendering the project); or 2) to rescue the project and subsidize it.

If the developer chooses project bankruptcy at the first stage or the government rejects to negotiate a subsidy (in a second stage), then the developer must pay a cost. Here, it is assumed that the payoff is 0, since the value of the equity shares held by the developer should approach zero prior to bankruptcy. In both cases, the government must retender the project with a cost associated with project retendering. Then, the payoff for the government is a new VfM given by $VfM_0 / (1 + \rho T)$, where VfM_0 is the initial or original positive value for money, ρ is the social discount rate and T is the waiting time until a new developer is contracted. The term $1/(1 + \rho T)$ may be thought of as a discount factor. In this sense, the new VfM implies that the larger the ρT , the smaller the new VfM is.

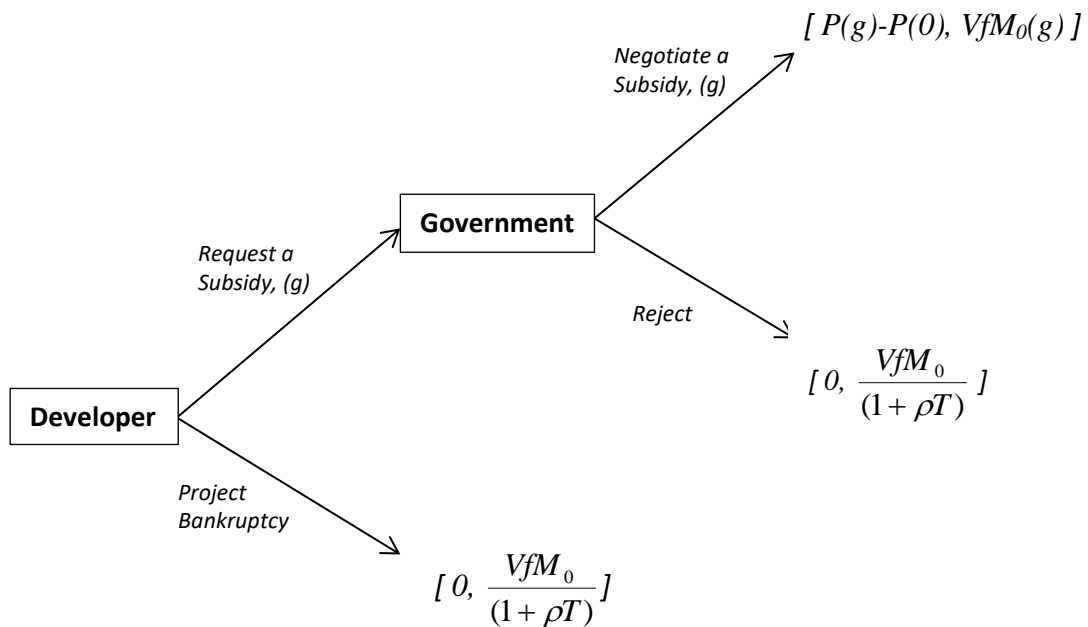


Figure 1. Renegotiation Game's Equilibrium Path. Source: own elaboration.

Alternatively, as shown in Figure 1, the Developer can negotiate subsidy g as a percentage

of the initial investment and the cost flow, thus obtaining an annual increment of the payoff $P(g)-P(0)$. After the developer's request for a subsidy, the government can reject the subsidy as mentioned before and receive a payoff $(0, VfM_0/(1+\rho T))$. However, if the Government decides to negotiate a subsidy, rescuing the developer will reduce the VfM from the original amount to $VfM(g)$. Therefore, the payoff to the developer and the government will be $(P(g)-P(0), VfM_0(g))$. Ho (2006) argues that there is a political cost associated with rescuing the project and subsidizing a private party. Cruz and Marques (2013) assert that renegotiation costs are difficult to calculate not only because there are different forms but also because the increased costs are frequently offset (at least in part) by certain benefits.

Note that the best developer strategy is to request a subsidy because failing to ask results in a payoff of 0 (and if the request is rejected, the payoff is 0), but it is also possible that the request will lead to a positive payoff of $P(g)-P(0)$.

The government has two options: "negotiate the subsidy" or "reject" the proposal. Guasch et al. (2014) posit that governments with weak institutions face a crucial tradeoff between canceling and renegotiating a PPP contract to avoid a potential bankruptcy, among other outcomes. Thus, the number of cancelled contracts in Latin America is low (but has been increasing over the last 30 years) at approximately 5% of total PPP projects granted. This rate is slightly higher than the average for developing countries, which is 4.3%.

The renegotiation will be the best strategy under the following condition:

$$VfM_0(g) \geq \frac{VfM_0}{(1+\rho T)} \geq 0 \tag{1}$$

The condition means that the impact of the reduction in the VfM resulting from the subsidy is less than the effect of retendering the project and waiting for a new developer to take on the project. Note that VfM is considered as the objective function of government. Following Kennedy (2013), the criterion for a PPP to be rescued is that it continues to provide greater VfM than other possible procurement methods, including retendering the PPP to another private party.

To understand this condition, the payoff model for the developer and the government must be explained. We consider a PPP project whose substance is to Design-Build-Finance-Operate-Maintain (DBFOM) a determined infrastructure. The developer will receive a constant disposal payment (P) from the government and let us assume for the sake of simplicity that the project is infinite in time and that the annual cost to operate and maintain the infrastructure is constant. The developer will receive a payment corresponding to a NPV equal to zero for a determined internal rate of return (IRR). The following is the developer NPV:

$$NPV = -\varepsilon I_0 + \int_0^{+\infty} [P - cI_0 - i(1-\varepsilon)I_0] e^{-kt} dt \tag{2}$$

where ε is the equity percentage, I_0 is the initial investment amount, c is the annual cost as a

percentage of the investment, i is the private interest rate and k is the IRR required for the project to be sustainable. These two financial variables will be expressed as follows: $i=r+p$ and $k=r+\sigma$. Thus, the private financial rate (i) is equal to the sovereign financial rate plus a spread (p), and the IRR is equal to the sovereign rate (r) plus the required risk (σ).

Solving the equation when $NPV=0$, the annual developer payment is obtained as shown in equation (3).

$$P = I_0(r + \varepsilon\sigma + (1 - \varepsilon)p + c) \tag{3}$$

The government must decide between traditional public procurement and pursuing the project through a PPP. Sarmiento (2010) remarked that VfM is one of the leading tools available to public managers to assess the value of pursuing a project through a PPP versus traditional procurement because it provides the public sector with a simple methodology to estimate the benefits, costs and risks involved in the project. Fatokun et al. (2015) assert that even if the importance of evaluating renegotiation in terms of VfM achievement is previously established, few empirically assess the relationship between these two concepts to address the challenge of under- or non-achievement of VfM in PPP road project transactions.

Equation (4) presents the VfM of an infrastructure project. The equation has two main terms. The first term shows the government cost of following the traditional option in which r is a public discount rate and δ is a parameter representing expected risk. This parameter is typically estimated in an infrastructure project using a percentage of cost overruns multiplied by the probability of cost overrun. Cost overruns are an important parameter determining the infrastructure risk. See for instance, Singh (2010), Arvan and Leite (1990), Cantarelli et al. (2010), Flyvbjerg et al. (2002), Flyvbjerg et al. (2003), Flyvbjerg et al. (2004). See Lee (2008) and Bansal and Kalady (2013) for the importance of cost overruns and their impact in infrastructure projects.

$$VfM = (1 + \delta)\left(I_0 + \int_0^{+\infty} cI_0 e^{-rt} dt\right) - \int_0^{+\infty} P e^{-rt} dt - (1 - \lambda)\delta\left(I_0 + \int_0^{+\infty} cI_0 e^{-rt} dt\right) \tag{4}$$

The second part of the equation represents the government cost if the project is pursued using the PPP option. In this sense, we have the flow of payments (P) to the developer and the proportion of the risk retained by the administration ($1-\lambda$). When the cost of the traditional public option is larger than the PPP option, VfM is positive and it will be efficient to pursue the PPP. Equation (4) can be simplified by (5).

$$VfM = (1 + \delta\lambda)\left(I_0 + \int_0^{+\infty} cI_0 e^{-rt} dt\right) - \int_0^{+\infty} P e^{-rt} dt \tag{5}$$

Solving the integrals in equation (5) and substituting the required payment presented in equation (3), we obtain the following expression of the VfM.

$$VfM = \frac{I_0}{r} [\delta\lambda(r + c) - (\varepsilon\sigma + (1 - \varepsilon)p)] \quad (6)$$

Note that equation (6) shows that VfM is positive when the percentage of the risk transferred that is associated with the public financing rate and the annual cost is greater than the weighted private risk and the required financial spread. Thus, if the developer has a high private risk or the financial spread is high with respect to the transferred public cost, it will be determined that the PPP option is not efficient. Arguments related to efficiency should explain why the private sector has a lower risk value than the public sector. Some authors assert that efficiency should be the only reason why the public sector is willing to pay a high price to the private sector. In fact, Engel et al. (2010) suggest that the higher cost of financing PPPs is not an argument in favor of public provision, since it appears to reflect both the combination of deficient contract design and the cost-cutting incentives embedded in PPPs. Thus, in the case of a correctly designed PPP contract, a higher cost of capital may be the price paid for the efficiency advantages accruing to PPPs.

Note that VfM is increasing with c , as the annual percentage cost of the project rises, it is more convenient to follow the PPP option. This finding suggests that projects with important costs relative to initial investment are more likely to be implemented using a PPP structure.

Even if equations (3) and (6) are the developer and government payoffs when the contract is signed, we are interested in the conditions contemplated when the project is negotiated. In this case, the developer NPV is recalculated using the following equation, in which g is the percentage of the initial investment and the annual cost.

$$NPV(g) = -\varepsilon I_0(1 + g) + \int_0^{+\infty} [P - cI_0(1 + g) - i(1 - \varepsilon)I_0(1 + g)]e^{-kt} dt \quad (7)$$

In this case, the developer will request a new payment determined by equation (8).

$$P(g) = I_0(1 + g)(r + \varepsilon\sigma + (1 - \varepsilon)p + c) \quad (8)$$

Equation (8) has an effect on the VfM of the government in determining a reduction with regard to the original amount when the developer won the tender, as shown in equation (9).

$$VfM(g) = \frac{I_0}{r} [(\delta\lambda - g)(r + c) - (1 + g)(\varepsilon\sigma + (1 - \varepsilon)p)] \quad (9)$$

Note that the renegotiation variable g has two effects on VfM. Increasing g will reduce the benefits of the PPP project, thus reducing the effect of the transferred risk and increasing the

private cost that is measured by the private risk and the financial spread.

Equation (9) is the payoff to the government of renegotiating the subsidy to the developer; in the case in which the request is rejected, the payoff is given by equation (10).

$$\frac{VfM}{(1 + \rho T)} = \frac{I_0}{r} \frac{[\delta\lambda(r + c) - (\varepsilon\sigma + (1 - \varepsilon)p)]}{(1 + \rho T)} \quad (10)$$

The renegotiation will result in a Nash equilibrium insofar as equation (9) will be larger than equation (10). Expression (11) shows the condition in which the request (g) made by the developer is consistent with the renegotiation equilibrium.

$$g \leq \frac{\rho T}{(1 + \rho T)} \frac{[\delta\lambda(r + c) - \varepsilon\sigma - (1 - \varepsilon)p]}{[r + c + \varepsilon\sigma + (1 - \varepsilon)p]} \quad (11)$$

Considering that VfM is positive, when the condition takes the equality, it makes no difference to the government to “renegotiate” or to “reject” the proposal. Notably, the renegotiation level is positively related to the social discount rate, the waiting time until the new developer takes on the project, the cost overrun, the level of transferred risk, the percentage cost, and the public interest rate and is negatively related to the private risk level, the financial spread requested by the financial system and equity level, since typically $\sigma - \rho > 0$.

5. Methodological proposal and the indicator of renegotiation

This section introduces two possible practical tools to analyze the decision of a government facing a renegotiation. The first methodology is based on the public sector comparator (PSC), and the second methodology is based on the design of a general indicator.

It is well known that the PSC is used by a government to make decisions about VfM in PPP projects. In fact, there are many government manuals in different parts of the world that consider this methodology. Examples of these manuals are the VDTF (2001) in Victoria-Australia, the PBC (2003) in Canada, the NTSA (2004) in South Africa, the DPER (2007) in Ireland, the Coulson (2008) in UK, the MAPPP (2008) in France, the Australian Government (2008) in Australia, the UTFP (2009) in Italy, the DNP (2009) in Colombia, the KDI (2010) in South Korea, the SHCP (2010) in Mexico, the MEF-CND (2012) in Uruguay, the MEF (2014) in Peru and the World Bank (2012) as a general guide. Based on these methodologies, to compute the VfM, we can establish a form to evaluate the convenience of renegotiation.

Sarmiento (2010) indicates that to compute the PSC, we need to estimate the public project cash flow including the full costs, revenues and risks discounted at the public sector rate to determine the NPV. Comparing this amount with the discounted value of payments (including the risks and costs retained by the public sector) to the private supplier, we obtain the

estimation of the VfM. The author also considers the convenience of conducting the PSC prior to the bid. Considering this method, which is also included in the abovementioned manuals, we can compute the VfM as in equation (12), where the present value of C_t represents the most efficient form of public procurement, the present value of P_t is the PPP provision, r is the public interest rate and N is the end of the concession.

$$VfM = \sum_{t=0}^{t=N} \frac{C_t}{(1+r)^t} - \sum_{t=0}^{t=N} \frac{P_t}{(1+r)^t} \quad (12)$$

Renegotiating implies $VfM(g)$, which is given by equation (13).

$$VfM(g) = \sum_{t=0}^{t=N} \frac{C_t}{(1+r)^t} - \sum_{t=0}^{t=N} \frac{(1+g)P_t}{(1+r)^t} \quad (13)$$

Rejecting the subsidy implies $VfM(\rho T)$, which is given by equation (14). Note that $(1+\rho T)$ is a discount factor indicating that the government has to postpone the project a time T .

$$VfM(\rho T) = \sum_{t=0}^{t=N} \frac{C_t}{(1+r)^t(1+\rho T)} - \sum_{t=0}^{t=N} \frac{P_t}{(1+r)^t(1+\rho T)} \quad (14)$$

There are two conditions for renegotiation: 1) $VfM(g) - VfM(\rho T) > 0$, where the VfM with the subsidy is larger than that to postpone the original VfM for a time T ; and 2) $VfM(g) > 0$, where the VfM is still positive with the subsidy, otherwise it is convenient to the public provision.

Rearranging $VfM(g) - VfM(\rho T)$, we obtain the equation (15). When R_{VfM} is positive, renegotiation will be convenient instead of retendering the project.

$$R_{VfM} = \frac{\rho T}{(1+\rho T)} \left[\sum_{t=0}^{t=N} \frac{(C_t - P_t)}{(1+r)^t} \right] - \sum_{t=0}^{t=N} \frac{gP_t}{(1+r)^t} \quad (15)$$

Note that computing derivatives of R_{VfM} with respect to g , ρ and T we obtain the expected results. On the one hand, $\partial R_{VfM} / \partial g < 0$ implies that the larger the subsidy, the lower the convenience to renegotiate. On the other hand, $\partial R_{VfM} / \partial \rho > 0$ and $\partial R_{VfM} / \partial T > 0$ implies that the larger the social discount rate (ρ) or the larger the time to postpone the project (T), the larger the convenience to renegotiate. One of the limitations of this indicator is the political cost, which is difficult to measure and to include. It is necessary to consider the evaluation of the political costs of saving the project and postponing the project. A second limitation is related to the ability to avoid the "winner's curse". In this case, it is difficult to compare the proposed renegotiation and the postponed project because it is necessary to work with a better estimation than the

$VfM_0/(1+\rho T)$, since the VfM_0 of the original winner project would be underestimated.

We can propose a more general second tool considering equations (9) and (10). This indicator has similar characteristics and limitations to those of the first tool, but it will be useful for examining the economic and financial relationships and analyzing the study cases. Considering condition (11), it is possible to define the “renegotiate” variable, R . This variable is positive when renegotiate is the more efficient decision and negative when rejecting renegotiation is the best strategy.

$$R = \{\rho T \delta \lambda - (1 + \rho T)g\}(r + c) - \{\rho T + (1 + \rho T)g\}(\varepsilon \sigma + (1 - \varepsilon)p) \quad (16)$$

where R is a function of a vector X of ten variables ($\rho, T, \delta, \lambda, g, r, c, \varepsilon, \sigma, p$). When complete information about the project is available for each element, R is calculated deterministically. However, when a variable in X is not known, a probability distribution will be assigned based on the empirical evidence. Therefore, it is possible to apply Monte Carlo simulations to obtain the simulated distribution of $R(X)$.

In particular, it will be informative to test the decision to renegotiate by a determined amount expressed as a percentage of the initial investment, which is easily obtained by computing $(P(g)/k - P(0)/k)/I_0$ –the difference between the total amount of payments following acceptance of the renegotiation minus the total amount of the original payment flows over the initial investment. The total cost of renegotiating as a percentage of I_0 is $g(k+c)/k$.

The next step is to make an assumption for each variable considering that the particular projects in some cases may have some information about some variables. For instance, ρ generally takes a value of 12% internationally. According to Esty (2000), ε typically takes a value that is between 10% and 35% in these types of projects compared with a range of 65% and 75% in industrial firms.

An important consideration should be noted in the case of the cost overrun variable, \square . This variable is typically modeled as normal, but some evidence indicates that it is not the most efficient distribution because the probability of obtaining variables larger than the mean is higher than obtaining variables lower than the mean. Although Flyvbjerg et al. (2002) assume that cost overruns are normal, a number of studies have shown that overruns are not normal. Love et al. (2014) find that cost overruns follow a generalized log-logistic distribution function. Bertisen and David (2008) argue that the evidence suggests that cost overruns are shifted lognormal. Horman (2001) highlights that a lognormal distribution best suit cost overruns because this distribution is best for stochastic estimates of cost variables, as shown by Wall (1997). Since most of the cost overrun information used in this study is based on Flyvbjerg et al. (2007), which provides only the mean and standard deviation, a generalized log-normal distribution will be approximated as the empirical cost overrun probability distribution function for simulations of R .

Table 2. Data inputs for the analysis of the percentages of PPP renegotiations

Variable	Code	LA	LA	LA	LA	US	France	France	UK
		Total	Electricity	Transport	Water	Highways	Highways	Parking	Total
Annual Cost ^(a)	c	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%
Public interest rate ^(b)	r	4.07%	4.07%	4.07%	4.07%	2.27%	3.13%	3.13%	3.13%
Equity ^(a)	ε	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%
Private interest rate ^(b)	i	5.32%	5.32%	5.32%	5.32%	4.02%	4.38%	4.38%	4.38%
Cost overruns (mean) ^(c)	δ	27.60%	27.60%	20.40%	33.80%	8.40%	22.40%	22.40%	25.70%
Transfer risk ^(a)	λ	80%	80%	80%	80%	80%	80%	80%	80%
Social discount rate ^(a)	ρ	12.00%	12.00%	12.00%	12.00%	12.00%	12.00%	12.00%	12.00%
Public waiting time ^(a)	T	3	3	3	3	3	3	3	3
IRR ^(b)	k	11.77%	13.85%	12.09%	12.96%	10.17%	11.11%	11.11%	9.95%
Renegotiations (%) ^(d)		68%	41%	78%	92%	40%	50%	73%	55%
Prob. Renegotiation ^(e)		22.68%	19.45%	14.31%	24.57%	3.94%	16.84%	16.83%	23.02%

Source: Own calculations. (a) Estimated parameters based on NAO (2009) and Esty (2000), and transfer risk in the BOO model suggested by Allan (2001) and Ho (2009); (b) Data from the Damodaran website: <http://people.stern.nyu.edu/adamodar/>; (c) Taken from Flyvbjerg (2007); (d) taken from Guasch et al. (2014); (e) The simulated probability that the estimated R is positive and then renegotiation is convenient.

Before conducting the analysis of the four case studies, an exercise was carried out to determine whether the level of PPP contract renegotiations might have some connection with the probability of renegotiating. Table 2 shows the input data for the exercise based on the levels of renegotiation presented by Guasch et al. (2014) for different sectors and regions, including Latin America (LA), United States (US), England (UK) and France.

It is important to clarify that Hasselgren et al. (2014) stipulate that one should be cautious with the conclusions obtained by analyzing the percentages of renegotiations. Due to practical differences in the nature and intrinsic particularities of each case, it is not advisable to use them to estimate the frequency of PPP renegotiation, considering that no important variables (such as the amount of investment projects requested in each case) are identified and their capacities and institutional strengths are not known.

The objective here is to show graphically whether there can be a relationship that presents a greater propensity to renegotiate because the probability of accepting a renegotiation is higher. For this, the information in Table 2 was used for each type of project. Monte Carlo simulations were conducted for a renegotiation request (g) of 10%, considering an order for an initial amount given, and the acceptance percentage of the renegotiation was taken therefrom.

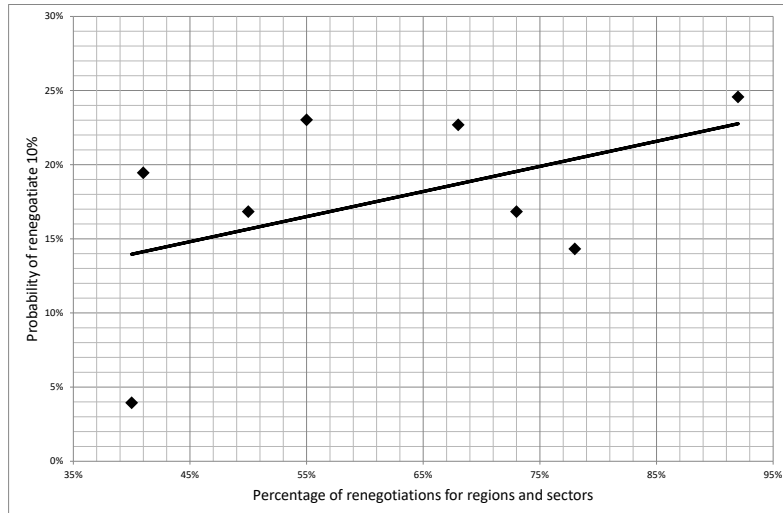


Figure 2. Percentage of renegotiations and the probability of renegotiation. Source: Own calculations based on data from Guasch et al. (2014)

Figure 2 shows the cloud of points between renegotiation and the percentages indicated by Guasch and the calculated probability. If a straight line is fitted, a positive correlation of 0.48 between the variables can be gleaned, which seems to suggest a possible relationship between the probability that renegotiation related to a project will be accepted and the percentage of renegotiations that were realized. Unfortunately, there is not more data to undertake a deeper analysis in this regard, although a more rigorous analysis requires considering each particular project and other variables, including institutional variables. In fact, Iossa and Saussier (2018) assert that weak institutions reduce the ability to transfer the risks and commitments assumed in the contract credibly. Furthermore, Iossa and Martimort (2016) indicate that weak political and regulatory institutions reduce the performance of PPP contracts by raising the risk of corruption.

Iossa and Saussier (2018) remark that the government's lack of commitment to renegotiate, as well as weak governance, explains the reasons for the frequent revisions of contracts in LA countries. In many of these countries, the regulatory agencies receive little training and instruments to carry out their mandate. In many cases, these agencies are under political control that affects their autonomy. Considering LA countries as a proxy of weak institutions and developing countries, a larger average renegotiation rate and probability are observed compared to developed countries. In fact, the average renegotiation rate in LA countries is 70% and the average probability is 20%, whereas in developed countries, the average renegotiation rate is 55% and the average probability is 15%. Note that the estimated probabilities seem to predict higher renegotiation rates in LA countries with respect to developed countries.

6. Case studies and empirical evidence

The following four case studies were selected considering the available information, the number of studies analyzing the cases and, principally, because they are from the same sector (light

railways) but differing governance environments. The China case was also selected as a control case, since it is an example of a successful project after two years of hard negotiations. The two European countries, UK and Portugal, are different. The UK economy (GDP of 2,629.20 billion in 2016) is larger than that of Portugal with an estimated GDP of USD 204.80 billion. According to Cruz and Marquez (2011), the latter country has the largest spending on PPPs as a percentage of GDP in Europe. China and Taiwan are from different governance environments in East Asia. China is the second largest economy in the world with a GDP of USD 11,218.30 billion and an economy that is highly regulated by the government. Chang (2013) argues that China is a latecomer to PPP practices, at least compared with developed countries. Historically, the Chinese private sector was strictly forbidden from getting involved in the construction and operation of any public infrastructure. Taiwan is one of the four Asian Tigers that underwent rapid industrialization and maintained exceptionally high growth rates. Nowadays, it has a high-income economy with a GDP of USD 528.60 billion in 2016.

Considering the Global Competitiveness Index 2017-2018 computed by the World Economic Forum, in terms of infrastructure, the UK ranked 11th, Taiwan 15th, Portugal 18th and China 46th. Note that there are differences with respect to the public sector performance; according to the same index, the UK ranks 15th, China 26th, Taiwan 38th and Portugal is in a far position at 95th.

According to Bing et al (2005), the UK prefers to allocate the majority of the risk to the private sector. On the contrary, Ke et al. (2010) found that preferences in China indicate that no risk fell solely on the private sector. Governance in Taiwan is also different from China with respect to the private sector. Chan et al. (2010) suggest that one of the major challenges to the successful implementation of PPP projects is the lack of an effective risk assessment model and an equitable risk-sharing mechanism. It is interesting to note that in the included project from China, 80% of the risks were allocated to the private sector, and the risks beyond the control of the private sector were shared or bore by the government.

Table 3 summarizes all the available parameters, assumptions and the computed R indicator for the four cases.

Case 1 corresponds to the London Underground, a metro system serving large areas of London, England. The information of this case is reported in the NAO (2009) and was analyzed by Kennedy (2013), Hallikeri (2015) and Sheikh et al. (2015). By the end of the 1990s, the public was becoming less confident about the safety and efficiency of the system. Several accidents had occurred on the London Underground, and the UK government announced a modernization program to be implemented by means of a PPP. NAO (2000) asserts that in March 2000, the contracts were expected to deliver £12-13 billion of capital and maintenance work during the first 15 years of the contract.

Table 3. Parameters of the four case studies

<i>Variable</i>	<i>Description</i>	<i>Metronet (UK)</i>	<i>MTS (Portugal)</i>	<i>THSR (Taiwan)</i>	<i>Metro Line 4 (China)</i>
C	Annual Cost/Investment	14.96%	14.96%	14.96%	14.96%
r	Public Interest Rate	3.50%	6.00%	4.07%	6.00%
ε	% Equity	12.00%	15.00%	25.00%	30.00%
σ	% Project Risk	7.61%	4.45%	8.89%	1.50%
i	Private Interest Rate	4.38% ^(a)	7.00%	5.32%	6.30%
p	Spread (<i>i-r</i>)	0.88%	1.00%	1.25%	0.30%
δ	Cost Overrun	(44.7%, 38.4%) ^(b)	(44.7%, 38.4%) ^(b)	(44.7%, 38.4%) ^(b)	(44.7%, 38.4%) ^(b)
λ	Transferred Risk	80.00%	80.00%	80.00%	(70%, 80%, 90%) ^(c)
ρ	Social Discount Rate	12.00%	12.00%	12.00%	12.00%
T	Social Waiting Time	(1, 2, 3) ^(c)	3	3	(2, 3) ^(d)
k	IRR	11.11% ^(a)	11.11%	12.96%	(7%, 8%) ^(d)
g(c+k)/k	Renegotiated Amount	43.90%	35.56%	12.20%	20.00%
R	Renegotiation Indicator	-0.03494	-0.02320	-0.00396	0.00174

Source: Own calculations. (a) The IRR and engineering/construction interest rate in Europe are taken from the Damodaran website: <http://people.stern.nyu.edu/adamodar/>; (b) Taken from Flyvbjerg (2007). Lognormal distribution is assumed (mean, standard deviation). (c) Triangular distribution is assumed (minimum, more probable, maximum). (d) Uniform distribution is assumed (minimum, maximum).

The contracts were bid on and won by two private consortiums, Metronet and Tube Lines. They were schedule to work over a 30-year period, beginning in 2004. However, by 2007, Metronet had already entered into insolvency administration after it could not meet its obligations. One important limitation is the lack of complete information; no one knew the conditions of the less accessible parts of the Tube's infrastructure, making difficult to accurately estimate the cost of future maintenance. Considering the cost uncertainty of the project, the government decided to break the 30-year project in four 7.5-year sections, allowing for periodic reviews. By 2010, Tube Lines had also entered into insolvency administration under similar circumstances. The result was that the PPP had completely failed, resulting in huge losses to the public and several government-led inquiries followed that heavily criticized Metronet and Tube Lines.

NAO (2009, p. 17) presents the cost structure of the Metronet project after 7.5 years: considering that investment is £4.1 billion and operational expenditures, administration and financing costs are £4.6 billion, the *c* is estimated as an average of 14.96% per year. The same report asserts that the government's discount rate, *r*, is 3.5% and the equity level is 12%.

Project risk was estimated to be 7.61%, based on the Damodaran website for information in the engineering and construction sectors in Europe, where the private interest rate is 4.38% and the IRR is 11.11%. Generally, transferred risk is approximately 80%, and the social discount rate is typically set at 12%. Cost overrun is modeled by applying a lognormal distribution, based

on Flyvbjerg et al. (2004), who indicate that the raw mean and standard deviation of rail projects are 44.7% and 38.4%, respectively. Flyvbjerg (2007) claims that there is no significant difference between urban and other types of rail in terms of cost overruns. Finally, social waiting time is modeled using a triangular distribution, with a minimum of 1 year and a maximum of 3 years until a new developer is operational.

According to NAO (2009), considering the 7.5 years, the capital expenditure was £4.1 billion and the developer required an additional £1.8 billion; this additional amount $(g(c+k)/k)$ represents 43.90% of the investment.

Note that applying VfM equation (6) to the project before the required amount generates VfM equivalent to £5.76 billion when applying the mean cost overrun of 44.7%. However, the impact of the 43.90% required by the developer would change the decision to maintain the contract. The government notes that for a period of 7.5 years, the expected investment was £4.1 billion, but the developer required an additional £1.8 billion (see Figure 3). Thus, evaluation of VfM must be undertaken in this context.

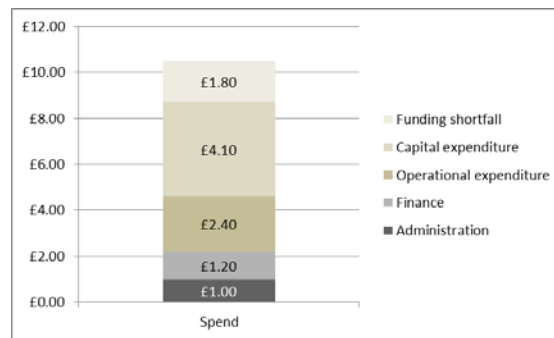


Figure 3. Metronet's project spend as of July 2007. Source: Own elaboration based on NAO (2009, p. 17). The first period runs from April 2003 to October 2007 (7.5 years).

In a deterministic context, considering a cost overrun of 44.70% and a social waiting time of 2 years until a new developer is operational, the R indicator is -0.03494. In fact, the decision of the government was to reject the proposal and reopen the project to public administration.

The simulated distribution of R is obtained running 1,000,000 trials. As shown in Figure 4, the probability of renegotiation is 2.72%, which means that under this structure, there is a 97.28% likelihood of rejecting the renegotiation.

Note that even when the convenience of renegotiation is clearly rejected, the government did not decide to tender the project, but decided to return the project to the public administration. According to Hallikeri (2015) the decision may be the correct one because there were difficulties in measuring costs and allocating risks, and in this case, undertaking a PPP is the wrong strategy for a public sector that seeks value for money.

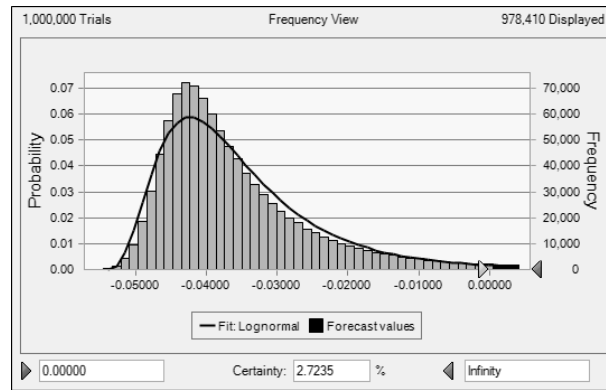


Figure 4. Simulated distribution of R for the Metronet Case. Source: Own calculation applying Crystal Ball.

Case 2 is the Metro Transportes do Sul (MTS) in Portugal. Information about the case can be found in Ferreira (2014). According to Cruz and Marques (2011), Portugal shows the largest PPP spending in Europe as a percentage of GDP. In fact, the use of the PPP model as a financing scheme has led to underestimations regarding future annual burdens, and the fiscal impact due to PPP renegotiations is high. One large PPP project is the concession of the southern Tagus surface metro to Metro Transportes do Sul (MTS).

In 1999, a tender was launched in connection with the project, pursuant to which the private partner would be responsible for the construction, equipment supply, and financing for the operation and maintenance (DBOFT) of the Southern Tagus surface metro. In 2002, the concession was awarded to MTS for 30 years.

IRR is estimated at 11.11% after reviewing the Damodaran website's cost of equity for engineering and construction in Europe. The public discount rate in the case of Portugal is 6%, whereas the social discount rate is 12%. The social waiting time is estimated at 3 years by calculating the period from the tender until the MTS was functional. As in the other cases, the cost overrun is modeled by applying the mean and standard deviation of rail projects at 44.7% and 38.4%, respectively. The private interest rate is 7% and the transfer risk is approximately 80%. The concessionaire contributed approximately 15%.

The total investment cost was € 284 million, and the VfM was € 283 million. The renegotiation implies a cost of € 101 million (35.56% of the investment) which in our case reduces VfM to € 127.31 million if renegotiation is accepted or € 181.08 million if the project must be retendered. In this case, the indicator R is -0.02320, which suggests not rescuing the concession.

Figure 6 shows the simulated distribution for the MTS case with an 11.39% probability of accepting the renegotiation and an 88.61% chance of rejecting it. Although the recommendation is negative, Portugal accepted renegotiations with MTS. Ferreira (2014) asserts that this case shows that the government's bad preparation when negotiating the concession contract led to its lack of decision power during the construction process.

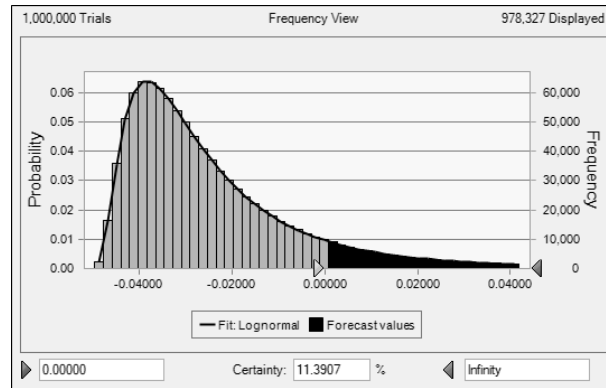


Figure 6. Simulated distribution of R for the MTS Case. *Source: Own calculation applying Crystal Ball.*

All this leads to a misallocation and an inadequate management of risk and renegotiation. Cruz and Marques (2011) stress that between 2002 and 2004, when renegotiations took place, a total of 8 ministers, 3 secretaries of state and 3 project leaders were involved in the project. From the public sector side, there was thus a clear governance problem, which weakened advocacy for the public interest when negotiating with the private sector (which is stable and builds up knowledge over time). This analysis (at least partially) explains why the government's decision does not match the recommendation of the indicator suggested under both deterministic and probabilistic result analyses. It is also consistent with the low world position of public-sector performance. Portugal has the worst rank (position 95) of the four countries in the public-sector performance index compared to the rest of the four countries

Case 3 corresponds to the High Speed Rail in Taiwan. The case information is reported by Dutzik et al. (2011) and also analyzed by Ho (2009). In 1998, the Taiwan High Speed Rail Corporation (THSRC) was awarded a 35-year concession to build and operate the Taiwan High Speed Rail (THSR), partially based on THSRC's promise to build the system without government financing. However, the company began to run into difficulties after the Asian financial crisis in the late 1990s, when it was forced to take out high-interest loans to pay for the project.

The investment cost is \$16.4 billion, the equity level is 25%, the social waiting time is 3 years, and the social discount rate is 12%. The annual cost as a percentage of the investment is considered the same percentage as in the Metronet case, i.e., 14.96%.

Project risk was estimated at 8.89%; the Damodaran website was again checked to determine that the private interest rate for the engineering and construction sectors in emerging markets was 5.32%; the IRR is 12.09%; and as discussed above, the transfer risk is approximately 80%. Cost overrun is modeled by applying a lognormal distribution, based on Flybjerg et al. (2004), using the raw mean and standard deviation for rail projects.

When the contract was executed, the VfM – including a cost overrun of 44.7% – is estimated at \$14.69 billion and even after including the \$2 billion requested by the developer, the VfM remained at \$9.63 billion. Considering that the VfM is \$9.4 billion if the contract is retendered,

the R indicator of -0.00396 suggests that it is not efficient to renegotiate the contract.

Figure 5 shows a simulated distribution of R obtained by running 1,000,000 trials. The probability of renegotiation is 28.32%, which indicates that under this structure there is a 71.68% chance of rejecting the renegotiation. Thus, the probability of renegotiation in this case is higher than in the Metronet one.

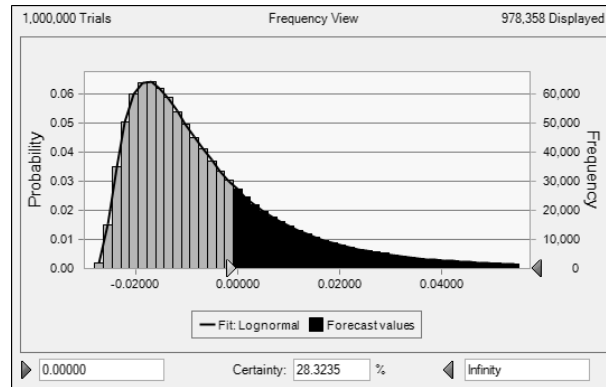


Figure 5. Simulated distribution of R for the High Speed Rail Case. Source: Own calculation applying Crystal Ball.

Ho (2009) contends that the Taiwanese case is an important project and that projects that are too important or too expensive for society to allow them to fail (or default) are not good candidates for PPPs. The costs requested are similar in both cases, \$1.8 billion in the Metronet case and \$ 2 billion in the THSR Case. However, the proportion of the investment is different; in the first case it represents 43.90% of the investment and in the High Speed Rail case, it represents 12.20%.

The Taiwanese government might have allowed the THSRC to go bankrupt and cease operations when the company ran into financial trouble. However, doing so would have resulted in the loss of a critical public asset, leaving the government with little choice but to prop up the failed business plan of a private developer with public funds. In any case, the indicator does not consider the mistakes made by the government. As mentioned, a megaproject is not a good candidate for a PPP and the political costs of not recuing such a project are very high. In addition, Ho (2009) indicates that the government was very aggressive at adopting PPPs for almost all public infrastructure projects, encouraging an opportunistic attitude and many related problems.

Case 4 is the Beijing Metro Line N°4 in China and the case was analyzed by Chang (2013), Liu and Wilkinson (2015) and Li (2017). This is an example of a successful case and renegotiation occurred during the negotiation of the contract. In this sense, the case is included as a control case to compare the results.

The latter authors claim that the project was the Mainland China's first PPP project involving the development and operation of an urban rail transit system. According to Chang (2013), the Beijing Infrastructure Investment Corporation (BIIC) decided to implement a PPP model for the

Beijing No. 4 line project for a 30-year period. The objective of the project was to accelerate Beijing’s metro development for the 2008 Olympic Games. In 2004, following a public tender process, the Beijing MTR Corporation was selected to undertake this development. The contract was under negotiation for one more year, and it was not finalized until 2006.

Liu and Wilkinson (2015) posit that IRR is estimated between 7-8%, and it is assumed that IRR is distributed uniformly between 7-8%. Chang (2013) indicates that the discount rate is 6%, the interest rate is 6.3% and the equity level is 30%. The annual cost is estimated at 14.96% (as in the previous cases), and the social discount rate is 12%. Considering the periods between the public tender and the operation of the developer, the time is distributed uniformly between 2-3 years. Transfer risk is assumed to be triangularly distributed (70%, 80%, 90%). Since the project is an urban railway, cost overruns are modeled by applying the mean and standard deviation of rail projects, which are 44.7% and 38.4%, as in the previous cases.

The total investment cost was \$2.4 billion, and considering a transfer risk of 80%, an average IRR of 7.5% and an average cost overrun of 44.7%, the VfM was \$2.73 billion. Renegotiation estimated a cost of \$480 million, representing 20% of the investment. According to Chang (2013), this percentage is usual for Beijing projects. Renegotiation would reduce the VfM to \$2.16 billion if renegotiation was accepted and to \$2.10 billion if the project was retendered. In this case, the indicator R is 0.00174, thus suggesting that the renegotiation should be accepted.

Figure 7 shows the simulated distribution for the Beijing Metro Line 4 case with a 39.38% probability of accepting the renegotiation. This probability is the largest among the four cases presented.

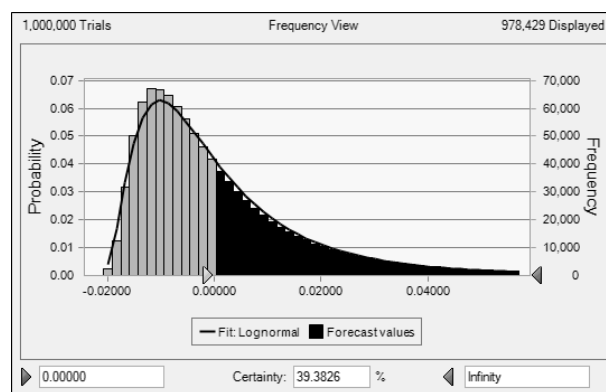


Figure 7. Simulated distribution of R for the Metro Line 4 Beijing Case. *Source: Own calculation applying Crystal Ball.*

We analyzed four cases of renegotiation for similar types of projects under different governances. It seems clear that the UK has the most solid institutions and the choice to not renegotiate according to the indicator was decided by the government. As mentioned, China was a control case because it is an example of a successful case, but note that it behaved as forecasted by the indicator. The outliers are the cases from Portugal and Taiwan.

Taiwan decided to renegotiate but the indicator suggested the opposite; however, in this case, there may be some issues not captured by the indicator. For instance, it is highlighted that the project is too important to fail and too expensive to default and there is a hidden cost of abandoning the project. It is also important to remark the economic context in Taiwan due to the Asian Crisis at the end of the 1990s and the increases in the interest rates, which would also affect the cost of retendering the project. In this situation, the VfM of retendering the project could be overestimated, but in any case, the project should not have been executed as a PPP.

Portugal renegotiated the project but the indicator has the largest probability of no renegotiation. This seems to be a clear case of weak governance, as suggested by Cruz and Marques (2011) and Ferreira (2014). It is also illustrative that Portugal has the worst rank in the public-sector performance index among the four countries. Marques (2017) considers that a contract alone does not protect the public interests; it is necessary to have regulations and an independent regulatory authority.

Note that even when these governments did not compute this indicator, we can see the potential to correctly predict the government's behavior in the cases of UK (rejecting renegotiation) and China (accepting renegotiation). Taiwan is a case where the project was not recommended as a PPP. Finally, Portugal is an example of the effects of a lack of regulations and poor performance of public institutions affecting the renegotiation decision.

7. Conclusions

This study aims to contribute to the study and analysis of the subject of financial renegotiations regarding PPP projects. Guasch et al. (2014) contend that the observed high incidence of renegotiations is a serious problem and thus question the effectiveness of PPP programs as a general matter, suggesting an abuse of the instrument and its use for opportunistic reasons rather for well-founded contractual reasons. Rozas et al. (2012) note that excess renegotiations are one of the main problems mentioned in the infrastructure development literature. As Hasselgren et al. (2014) argue, renegotiation should not be treated casually. It should be used only exceptionally, as the direct effect will typically be adverse to the public interest.

The reason to develop useful tools for policy makers when deciding to renegotiate a PPP is well established by Ho (2006). In fact, Ho (2006) emphasizes two reasons related to the problems of asymmetric information, i.e., the principal-agent problem and moral hazard. The first occurs when a future developer knows that a request for renegotiation is generally (or even always) granted; in that case, he would then have substantial incentive to bid optimistically to

win the project regardless of costs. The reason that an overly optimistic proposal can have a higher chance of winning is because some crucial and developer-specific information regarding the project is difficult for the government to verify and can be untruthfully revealed in the development proposal as a result. The second reason occurs after the contract is signed: if renegotiation is expected, the developer may engage in inefficient actions that will reduce overall social efficiency but increase the developer's ultimate payoff.

In this context, we employed the dynamic game-theoretic framework involving financial renegotiation developed by Ho (2006). In this way, we made contributions regarding the incorporation of payment functions that allow conclusions regarding the influence of certain variables in the renegotiation of a PPP project. In addition, we were able to apply the model in the real world. Considering the applied computation of the VfM based on the PSC, we propose a method for estimating the convenience of renegotiation versus postponement of the project. This method can be practically computed given that the VfM is generally estimated in many countries such as the UK, which explains the method in Coulson (2008). Of course, the indicator suffers from the same limitations as the PSC. Large transfer risk does not assure more VfM as this does not represent an optimal risk allocation between the public and private sectors. A context of weak governance and the lack of regulations does not ensure the reliability of the results. The political costs of retendering or rejecting the project are difficult to estimate, even if in some cases they could be compensated. The effects of asymmetric information affect the indicator. For instance, the winner's curse can overestimate the VfM. For this reason, we consider the important recommendation of Sarmiento (2010) to make the effort to conduct a PSC prior to the bid.

We also derived an alternative R indicator to distinguish when a project was more likely to be renegotiated. According to the indicator obtained, whether a PPP project should be renegotiated positively depends on the social discount rate, public waiting time, extra costs, level of risk transferred, percentage of cost and the public financing interest rate and negatively depends on the level of private risk, the spread required by the financial system and the equity level.

In the present work and due to limited information, we applied the second indicator to four case studies of PPP projects in which renegotiations were requested. We note that in the UK case, which has more solid institutions, the decision to not renegotiate is in accordance with the results of the indicator. China also behaves as suggested by the indicator by renegotiating the project. The Taiwan case is more complicated due to the financial crisis that affected the region. In this case, large interest rates may affect the VfM of retendering the project and may not be considered in the computation of the indicator. However, the main mistake was to adopt a very important and expensive project as a PPP. Finally, Portugal seems to be a clear case of weak governance, and the indicator suggested not renegotiating with a probability of 11.39%. However, the government renegotiated the conditions with the developer for reasons explained by Ferreira (2014) and Marquez and Cruz (2011). These authors blame this miscalculation on a weak government position when renegotiating due to personnel changes in the public stakeholders (there were 8 different ministers, 3 secretaries of state and 3 project leaders

involved) and poor government preparation of concession contracts. It is clear that asymmetric information and know-how differences between the companies and the government are large, as suggested by Marques (2017). Note also that Portugal, as mentioned above, has the worst rank (position 95) of the four countries in the public-sector performance index compared to the rest of the four countries. In fact, considering the efficiency of the legal framework for settling disputes, Portugal ranks 121st out of 137 countries. Marques (2017) asserts that contract management is not enough and does not replace renegotiation, highlighting the important role of an independent regulator.

The R indicator is more theoretical and its application in this paper is based on poor information about the different analyzed projects because the indicator is used to study relations between economic and financial variables and the correct decision. However, we consider that the alternative indicator based on the PSC could be estimated by the government, since it utilizes many of the available tools applied to compute the VfM. Although the indicator can be improved, it can be used as an additional tool when analyzing the convenience of renegotiation.

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