Design Contract for Public-Private Partnerships: A theoretical model for Brazilian hospitals

Rodrigo Nobre Fernandez * André Carraro† Gabrielito Menezes ‡
Giácomo Balbinotto Neto§ Eduardo Tillmann¶

Abstract: Public-private partnerships (PPP) are a new model of public contracting which consist of the contractual relationship between public and private agents. Some of its most important aspects are risk-sharing between the involved parties and the possibility of investments in infra-structure that are above or beyond or higher than the budget constraints of the State. This work has evaluated a theoretical model of PPP applied to hospital building in Brazil. It has verified the existence of the moral hazard problem when carrying out contracts for clinical services and with maintenance companies. When there is a subcontract, this inconvenience implicitly shows up so, the realization of separate contracts, is the best available alternative. In brief, these partnerships represent a good mechanism of public policy, if the State establishes, in the best possible way, the contractual rules that specify the necessary level of quality for a determined service.

Key-Words: Public-Private Partnerships, Public Contracts, Moral Hazard.

JEL Classification: H51, H54, D82.

Resumo: As Parcerias público-privadas (PPP) são um novo modelo de contração pública que consiste na relação contratual entre o ente público e o privado. Alguns de seus aspectos mais relevantes é o compartilhamento de riscos entre as partes envolvidas e a possibilidade de investimentos em obras de infra-estrutura superiores à restrição orçamentária do Estado. Este trabalho avaliou um modelo teórico de PPPs aplicado a construção de hospitais no Brasil. Verificou-se a existência do problema de risco moral na realização de contratos com empresas de serviços clínicos e de manutenção. Quando há um subcontrato este inconveniente acontece implicitamente, sendo a realização de contratos descentralizados a melhor alternativa disponível. Em suma, estas parcerias representam um bom mecanismo de política pública se o Estado estabelece regras contratuais que especifiquem, da melhor forma possível, o nível de qualidade necessário de determinado serviço.

Palavras Chave: Parcerias-Público Privadas, Contratos Públicos, Risco Moral.

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Área 4 - Economia do Setor Público.

*Student of PPGE/UFRGS. rodrigo.fernandez@ufrgs.br
†Professor of PPGOM/UFPEL. andre.carraro@ufpel.edu.br
‡Student of PPGE/UFRGS. gabrielito.menezes@ufrgs.br
§Professor of PPGE/UFRGS. giacomo.balbinotto@ufrgs.br
¶Student of PPGE/UFRGS. eduardo.tillmann@ufrgs.br

1 Introduction

Recently, governments all over the world have been searching for new tools to promote infrastructure investments. In the mid-90s Public-Private Partnerships[1] emerged, which can be defined as long term contracts between public and private agents, to deliver a service, which was traditionally provided by the State. Furthermore, PPPs have a lot of configurations and they might assign one or many tasks to the private partner that may include design, financing, development or repair of a work or service (CEC, 2004).

In this perspective, this works develops a theoretical model for the construction of new hospitals in Brazil through the formation of PPPs. For this purpose, we evaluate different scenarios of hiring, i.e., the State can make separate contracts among maintenance companies, contractors and providers of clinical services or, offer an alternative, for the construction firm to outsource maintenance. In short, we intended to analyze whether the problem of asymmetric information interferes in the provision of these contractual arrangements and what is the best available alternative for the partnership formation.

Since they were first conceived, PPPs are mostly used in much of continental Europe, the United States and Chile. Their highest concentration occurs in the sectors of health, sanitation, prisons, highways and schools (EUROPEAN REPORT PPP, 2009). It is worth mentioning the role of the United Kingdom, not only as the precursor of this type of contractual relationship, but as having been able to sign over 700 projects during the period 1998-2006 (HM TREASURY, 2006).

In the Brazilian context, PPPs are regulated by law nº 11079 of December 30, 2004. According to the Ministry of Planning, Budget and Management[2], during the period 2009-2010, the Federal Government signed some contracts based on this form of arrangement. As examples, we should mention the management of a Data Centre for two public banks, the Caixa Econômica Federal together with the Banco do Brasil, a project to increase irrigation of crops in the state of Pernambuco and the implementation of the Digital Television Network. Under the state and city sphere, some partnerships are currently in progress, such as a new line for the São Paulo subway system and a highway, the MG-050, in the state of Minas Gerais, among others[3].

A caveat that must be made when comparing Brazil to other countries that have succeeded in the adoption of PPPs, such as Germany, Spain, Portugal and the UK, is that they have a stronger institutional backing to such partnerships. That is, institutions and government are more consolidated, making it easier to achieve economic efficiency, and there is also a wider range of instruments available in order to induce transparency to the actions performed.

In this perspective, the use of PPPs allows greater flexibility of the State in meeting public policy, given the risk-sharing between the public and private agents. This flexibility enables the expansion of the State's capacity to carry out new investments. Thus, this new form of contract can provide a solution to the public investment problem, such as infrastructure bottlenecks, with the advantage of the productive efficiency of the private sector.

On the other hand, when this type of partnership is established, the government loses some of its autonomy over the execution of the project. Thus, the public body cannot properly monitor the quality level of the work. This becomes clearer in the case of a PPP to build a new hospital. In this case, the quality issue is intrinsically linked to the result of the construction process. However, firms may have incentives to reduce costs and thus, if these factors are not clearly stipulated by the contract, they can compromise the final outcome of the project

[1] PPPs or 3Ps.

[2] See http://www.planejamento.gov.br/hotsites/ppp/conteudo/projetos/projetos.html

[3] PPPs are being used as a public procurement tool for the rebuilding of stadiums such as, Fonte Nova in Bahia and Mineirão in Minas Gerais, because of the 2014 World Cup which will be held in Brazil.

(BOADWAY; MARCHAND, SATO, 2004; MARTIMONT; IOSSA, 2009).

These difficulties do not overcome the benefits linked with new investments in the health sector. The lack of investment in new hospitals and the technological gap of public institutions, relative in relation to private ones, are evidence of the need for new alternatives, besides the government as sole investor. Therefore, PPPs are internationally proven as a tool for the expansion of public investment policies in the public health sector (NISHTAR, 2004).

This evidence corroborates with the necessity of investment in the construction of new public hospitals in Brazil[4]. As it was already emphasized by Duarte (1999), there is a shortage in the number of beds available in Brazilian hospitals, which highlights the need for new investment. Medical health care research, conveyed by the Brazilian Institute of Geography and Statistics (IBGE), reports that from 1999 to 2009, the discrepancy between the growth of population and the existing number of beds, is increasing. This lack of investment in new hospitals, according to Lopes (2012), is a fact that should be carefully evaluated by the State.

Within this scope, Arrow and Lind (1970) state that, all decisions of public entities, such as whether to make a new investment, involve a certain level of uncertainty. This factor is a major concern, particularly with new contracts, and it can be attributed to different informational levels among agents. This information asymmetry causes difficulties relating to the quality level of the services to be performed in the health sector (SHERMAN, GOODMAN, STANO, 2008).

Thus, this work is divided into five sections, beginning with this introduction. In section two, it presents a literature review. The two following sections present the model and discuss the results. After that, the final considerations are shown.

2 Theoretical Framework

The providing of health services are key factors for the level of social welfare. This point is emphasized by Arrow (1963), being that, government investments in infrastructure and training of qualified staff are very well regarded by the population. In this sense, it should be highlighted that quality is an extremely important factor, which must be taken into account when establishing a contract. For example, it is necessary to carefully consider the materials that will be used for the construction of the hospital, as well as the disposition of the hospital beds, the technological level of the equipment and the technical capacity of health professionals, etc.

In this regard, Bos and Fraja (2002) developed a model in which the State establishes a contract with a private hospital, where the first tends to protect itself by simultaneously negotiating with other suppliers. Assuming that the private company knows this action, it tries to protect itself by offering a better service. Thus, even when the agents face this uncertain environment, the outcome is a better quality service, and therefore, an improved level of social welfare.

In this context, the process of asymmetric information has great importance in the paradigm of incomplete contracts. This idea is very important for the studies of health economics, given that it may influence the negotiation between the suppliers and buyers of the hospital services.

When drawing up a PPP contract, the asymmetric information problem is characterized when one of the parties involved, (whether firms or governments), have exclusive access to

[4]Hospital do Subúrbio, located in the metropolitan region of Salvador in the State of Bahia, was the first hospital made viable through a PPP. This unit focuses on urgent care and will be operated by the winning consortium Prodal Saúde Inc. For more information see: http://www.sefaz.ba.gov.br/administracao/ppp/projeto_hospitalsuburbio.htm

certain information or different sets of information. This problem, generally involves two dimensions: an exogenous one (adverse selection) and another endogenous one (moral hazard[5]).

Using the analogous arguments of Akerlof (1970), adverse selection will occur when, for example, the public entity hires a certain service at the lowest possible cost, but cannot properly assess the quality that will be supplied under the provision of the service. According to Spence (1973), a way of reducing the adverse selection problem is to verify what the author calls "signs", which are demonstrations or samples of performance. A good way to understand how the government might develop this task is to take into account the company's portfolio[6]. The analysis of services and activities previously provided by the company can supply interesting information about the commitment and quality of the entity.

However, this verification process results in additional costs. Within this approach, these expenditures would be incorporated into the opportunity costs, of public and private sectors, when signing the contract. Even if "signaling" is important for reducing information asymmetry, these expenses could be implicit within competitive markets.

In the perspective of Rothschild and Stiglitz (1976), when markets are in an environment of imperfect information, they might generate interesting results, as well as the impossibility to establish an only price that would determine the market equilibrium. From this, stems what is called "screening", i.e., the establishing of certain specifications which will induce the selection of the proper members, in the best feasible way, to the signing of a contract. This point will be reached, in the case of PPPs, when the State selects its private partners for the accomplishment of specific activities in these projects.

Thus, it can be said that all PPP contracts fit into the Milgrom and Holmstrom (1991) approach, in which the authors assess what is known as the principal-agent problem. In this type of contractual arrangement, the government is considered the principal, because it is responsible for the contract, and the company is taken as the agent, which verifies whether the work offer is relevant. According to Sappington (1991) the aim is to provide incentives to attract the type of agent, appropriate for the principal's needs. However, the agent will only accept the contract if the proposal received is better than the market alternative or, at least, if the offer is above its level of buffer utility[7].

Furthermore, it might be less costly for the principal to induce the agent to adapt its performance, if the environmental conditions vary with the course of time. If the principal has more or better information than the agent, it would probably not want to share this information with it. So, according to Sappington (1991), the level of information can be deterministic in the creation of PPPs, mainly in the process of renegotiation after the signature of the contract.

Within this context, Barros and Giralt (2009) summarize these differences in the structures of PPP contracts. The first involves gathering investment and service provision within a single contract. The second one, which is the most common in the health care sector, is characterized by having two different contracts, one for investment and another for the provision of the service.

Hence, this work uses Barros and Giralt's (2009) proposal as its reference, and develops a contract model, according to the Brazilian institutional characteristics. Besides, we verify how the information asymmetry problem turns up in this context, essentially regarding the difficulty of monitoring quality, both during the building of the hospital as well as in the provision of health services after the work is finished.

[5]Moral hazard occurs, because only the firm knows the results of certain intrinsically endogenous moves, such as, management costs and which allows it to change these values to obtain some advantage when contracts are defined.

[6]Portfolio is a set of stock or assets belonging to a firm. It is thought that customers can be considered as components of the company's portfolio because of their importance to the business.

[7]The minimum level of remuneration for the firm to accept the offer.

3 The PPPs model for Hospitals

In the health sector there are essentially two types of PPP contracts. According to Souza (2009), the first is concerned exclusively with the construction and maintenance of infrastructure and management of the hospital. The second one focuses on construction and building maintenance.

In these models, the state sets prices according to what is negotiated with the private agent. Thus, the moral hazard problem is implicit, because firms have incentives to minimize costs and increase their profits, which, in the area of hospital service provision[8], can result in loss of quality which cannot be fully measured and/or observed by the public sector[9].

Within this context, Barros and Giralt (2009) present a model where the government prepares various contracts for the establishment of PPPs, aimed at the construction and provision of hospital services. In short, the State separately hires construction companies and providers of clinical services and, one of them, becomes responsible for hiring a firm intended to perform the maintenance services.

In this perspective, it is assumed that, in the Brazilian case, the most convenient step is to analyze the situation where the public entity conducts a partnership agreement with a provider of clinical services and, this firm, will not perform any other subcontract. On the other hand, the builder has the option of performing a consortium that allows the company intended to subcontract maintenance services.

When the government signs a contract with a firm that provides clinical or maintenance services, it cannot effectively monitor the quality of the service, since this fact is intrinsically related to the technical capacity of the professionals who will perform this function. Nevertheless, when hiring a construction company to build a hospital, for example, it becomes easier to observe other outcomes of the final product, even though both, the disposal and the types of material used are harder to observe and will have an impact on the final assessment of the quality of the building.

Thus, we formally present the four scenarios of PPP contracts in an environment of asymmetric information. The following subsection shows the model assumptions.

3.1 Model Assumptions

First of all, we must think of a production function of health services or benefit *B(x,q,k)* where x is the input level (inputs) of clinical services, q is the quality of maintenance companies, and k is the investment in construction companies. This function should be *twice continuously differentiable*[10] in all its parameters.

Another important point is the provision cost of clinical services, maintenance and construction, that can be respectively expressed by the following functions: *C(q, x)*, *S(q, k)* and *H(k)*. It should be noted that marginal costs are increasing in all activities and also considers the existence of *economies of scope*[11].

Briefly, the result of production function B is known by the government, though the individual parameters are not. On the other hand, the costs functions of each firm are not known

[8] Building, maintenance, management etc.

[9] There are fees for monitoring the "quality", but their observation in some cases is quite complicated, such as the assistance received by patients of health professionals or hospital staff.

[10] The function must be continuous in all its derivatives or be considered Class C^2. Although it is not a necessary condition, in economic terms this means that there are one or more points of maximum or minimum.

[11] According to Macho-Stradler and Perez-Castrillo (2009) a hospital that performs a general type of service is considered, so the costs would be reduced by using the same physical structure, as well as the same professionals, to perform various functions. That is, if a hospital was built for a specific activity, this assumption could not be used.

by the State. Formally we have:

$$SW(x,q,k) = B(x,q,k) - C(q,x) - S(q,x) - H(k) \tag{3.1}$$

As shown in equation (3.1), the agent's public objective is to maximize the SW (social welfare) function, which is defined as the patients' net social benefits deduced from the total cost, the latter being the sum of all costs involved for the hiring of the companies providing construction, maintenance and provision of clinical services. Furthermore, as the set of information is different, between the government and the company, there is a post-contract information asymmetry problem, i.e., in certain situations moral hazard may arise. Here we analyze in which of these scenarios these relations might arise.

3.2 Evaluation of Scenarios

In this way, four scenarios are developed, that include the considerations that are most relevant to the national scene, as follows:

3.2.1 Scenario 1: The state hires a clinical services provider

When signing a PPP with the firm providing clinical services, the State will try to hire a company that has the most qualified group of professionals at the lowest possible cost. In this situation, it incurs the moral hazard problem, since the public entity will have difficulties in effectively monitoring the quality of services provided. Explaining these considerations formally we have:

$$Max\, W^G = V^G\left(B(x,q,k), \Pi^G\right)$$

subject to

$$W^C = V^C\left(B(x,q,k), \Pi^C\right) \geq \overline{V} \text{ [Participation Constraint]}$$

$$\frac{\partial W^C}{\partial q} = 0 \text{ [Incentive Compatibility Constraint]}$$

Where:

The objective function of the State: $W^G = V^G\left(B(x,q,k), \Pi^G\right)$;

The payment made to providers of clinical services is represented by:$T = a_0 + a_1 C(x,q)$;

The profit or surplus of the State is: $\Pi^G = B(x,q,k) - a_0 - a_1 C(x,q)$;

The wage or profit providers of clinical services: $\Pi^C = T - C(x,q) = a_0 + (a_1 - 1)C(x,q)$;

This problem can be solved using Lagrange multipliers:

$$L_{\{x,q,a_0,a_1,\lambda_1,\lambda_2\}} = V^G + \lambda_1\left[W^C - \overline{V}\right] + \lambda_2\left[\frac{\partial W^C}{\partial q}\right]$$

Obtaining the first order conditions (FOC):

$$\frac{\partial L}{\partial x} = \frac{\partial V^G}{\partial B}\frac{\partial B}{\partial x} + \frac{\partial V^G}{\partial \Pi^G}\frac{\partial \Pi^G}{\partial x} + \lambda_1\frac{\partial W^C}{\partial x} + \lambda_2\frac{\partial^2 W^C}{\partial q \partial x} = 0 \tag{3.2}$$

$$\frac{\partial L}{\partial q} = \frac{\partial V^G}{\partial B}\frac{\partial B}{\partial q} + \frac{\partial V^G}{\partial \Pi^G}\frac{\partial \Pi^G}{\partial q} + \lambda_1 \frac{\partial W^C}{\partial q} + \lambda_2 \frac{\partial^2 W^C}{\partial q^2} = 0 \tag{3.3}$$

$$\frac{\partial L}{\partial a_0} = \frac{\partial V^G}{\partial \Pi^G}\frac{\partial \Pi^G}{\partial a_0} + \lambda_1 \frac{\partial W^C}{\partial a_0} + \lambda_2 \frac{\partial^2 W^C}{\partial q \partial a_0} = 0 \tag{3.4}$$

$$\frac{\partial L}{\partial a_1} = \frac{\partial V^G}{\partial \Pi^G}\frac{\partial \Pi^G}{\partial a_1} + \lambda_1 \frac{\partial W^C}{\partial a_1} + \lambda_2 \frac{\partial^2 W^C}{\partial q \partial a_1} = 0 \tag{3.5}$$

$$\frac{\partial L}{\partial \lambda_1} = W^C - \overline{V} = 0 \tag{3.6}$$

$$\frac{\partial L}{\partial \lambda_2} = \frac{\partial W^C}{\partial q} = 0 \tag{3.7}$$

Isolating in λ_1 (3.4), substituting it in (3.5) we are able to find, $\lambda_2 = 0$.

Utilizing this outcome in (3.4), we can find:
$\lambda_1 = -\frac{\partial V^G}{\partial W^C}$.

Substituting the values of λ_1 and λ_2 in (3.2) and using the outcome from (3.7):

$$a_1 = \frac{\frac{\partial B}{\partial q} + \frac{\partial B}{\partial C}|q}{1 + \frac{\partial C}{\partial q}}$$

The result found for a_1 suggests that this parameter represents the sum of the variation of the benefit function in relation to the quantity and the costs divided by one plus the variation of the cost function in relation to quality.

Analysis of result 1:

When the government hires a clinical service providers, the moral hazard problem emerges, because the public entity cannot accurately monitor the variation of the q parameter after the signing of the contract. This means that, if health professionals marginally modify their level of effort, the cost impact may be barely noticeable, but the quality of the services will decrease. In this case, this amounts to the condition of *second-best*[12] precisely because the government faces the monitoring problem.

3.2.2 Scenario 2: The state hires the building contractor

In this scenario the State establishes a PPP with the company that will build a new hospital. Thus, it is assumed that the government can properly observe the quality of the project, repeating that the quality of material used and the way in which the project is being developed, according to its cost, can influence the quality of the institution where sick people are being received. Thus, we have the following:

[12]The *second-best* theory comes up with Lipsey and Lancaster, (1956-1957) where the authors report that this result is possible when any of the optimum conditions are not met, as well as in moral hazard case.

$$Max\, W^G = V^G\left(B(x,q,k), \Pi^G\right)$$

subject to

$$W^H = V^H\left(B(x,q,k), \Pi^H\right) \geq \overline{V} \text{ [Participation Constraint]}$$

Where:

The objective function of the State is: $W^G = V^G\left(B(x,q,k), \Pi^G\right)$;

The payment made to contractor is represented by: $T = b_0 + b_1 H(k)$;

The profit or surplus of the State is: $\Pi^G = B(x,q,k) - b_0 - b_1 H(k)$;

The contractor's wage or profit: $\Pi^H = T - H(k) = b_0 + (b_1 - 1)H(k)$;

This problem could be solved using Lagrange multipliers:

$$L_{\{k,b_0,b_1,\lambda_1\}} = V^G + \lambda_1\left[W^H - \overline{V}\right]$$

Obtaining the FOC:

$$\frac{\partial L}{\partial k} = \frac{\partial V^G}{\partial B}\frac{\partial B}{\partial k} + \frac{\partial V^G}{\partial \Pi^G}\frac{\partial \Pi^G}{\partial k} + \lambda_1\frac{\partial W^H}{\partial k} = 0 \tag{3.8}$$

$$\frac{\partial L}{\partial b_0} = \frac{\partial V^G}{\partial \Pi^G}\frac{\partial \Pi^G}{\partial b_0} + \lambda_1\frac{\partial W^H}{\partial b_0} = 0 \tag{3.9}$$

$$\frac{\partial L}{\partial b_1} = \frac{\partial V^G}{\partial \Pi^G}\frac{\partial \Pi^G}{\partial b_1} + \lambda_1\frac{\partial W^H}{\partial b_1} = 0 \tag{3.10}$$

$$\frac{\partial L}{\partial \lambda_1} = W^H - \overline{V} = 0 \tag{3.11}$$

Isolating λ_1 in (3.9) or (3.10) we have: $\lambda_1 = -\frac{\partial V^G}{\partial W^H}$.

Using λ_1 in the equation (3.8) and solving for b_1:

$$b_1 = \frac{\partial B}{\partial H}\,|q$$

The result found for b_1 suggests that this parameter represents the variance between the benefit function and the production function of construction services.

Analysis of result 2:

When the government establishes a PPP contract with a construction company it is assumed that it can effectively monitor the progress of the project. In this way we have that the result found for $b_1$indicates that there is a *first-best*[13] situation.

[13]We consider that this understanding comes from the first theorem of welfare. It states that a competitive equilibrium is Pareto-Optimum, thus, ensuring the condition of first-best.

3.2.3 Scenario 3: The state hires the maintenance service company

In this situation the state conducts a PPP with the company that will provide maintenance services at the hospital. Assuming the government cannot effectively monitor the activities of this company, then it faces the moral hazard problem. Explaining these considerations formally we have:

$$Max\, W^G = V^G\left(B(x,q,k), \Pi^G\right)$$

subject to

$$W^S = V^S\left(B(x,q,k), \Pi^S\right) \geq \overline{V} \text{ [Participation Constraint]}$$

$$\frac{\partial W^S}{\partial q} = 0 \text{ [Incentive Compatibility Constraint]}$$

Where:

The objective function of the State is: $W^G = V^G\left(B(x,q,k), \Pi^G\right)$;

The payment made to maintenance companies: $T = w_0 + w_1 S(q,k)$;

The profit or surplus of the State is:$\Pi^G = B(x,q,k) - w_0 - w_1 S(q,k)$;

The wage or profit of the maintenance company:$\Pi^S = T - S(q,k) = w_0 + (w_1 - 1)S(q,k)$;

This problem could be solved using Lagrange multipliers:

$$L_{\{q,k,w_0,w_1,\lambda_1,\lambda_2\}} = V^G + \lambda_1\left[W^S - \overline{V}\right] + \lambda_2\left[\frac{\partial W^S}{\partial q}\right]$$

Obtaining the FOC:

$$\frac{\partial L}{\partial k} = \frac{\partial V^G}{\partial B}\frac{\partial B}{\partial k} + \frac{\partial V^G}{\partial \Pi^G}\frac{\partial \Pi^G}{\partial k} + \lambda_1\frac{\partial W^S}{\partial k} + \lambda_2\frac{\partial^2 W^S}{\partial q \partial k} = 0 \tag{3.12}$$

$$\frac{\partial L}{\partial q} = \frac{\partial V^G}{\partial B}\frac{\partial B}{\partial q} + \frac{\partial V^G}{\partial \Pi^G}\frac{\partial \Pi^G}{\partial q} + \lambda_1\frac{\partial W^S}{\partial q} + \lambda_2\frac{\partial^2 W^S}{\partial q^2} = 0 \tag{3.13}$$

$$\frac{\partial L}{\partial w_0} = \frac{\partial V^G}{\partial \Pi^G}\frac{\partial \Pi^G}{\partial w_0} + \lambda_1\frac{\partial W^S}{\partial w_0} + \lambda_2\frac{\partial^2 W^S}{\partial q \partial w_0} = 0 \tag{3.14}$$

$$\frac{\partial L}{\partial w_1} = \frac{\partial V^G}{\partial \Pi^G}\frac{\partial \Pi^G}{\partial w_1} + \lambda_1\frac{\partial W^S}{\partial w_1} + \lambda_2\frac{\partial^2 W^S}{\partial q \partial w_1} = 0 \tag{3.15}$$

$$\frac{\partial L}{\partial \lambda_1} = W^S - \overline{V} = 0 \tag{3.16}$$

$$\frac{\partial L}{\partial \lambda_2} = \frac{\partial W^S}{\partial q} = 0 \tag{3.17}$$

Isolating $\lambda_1$in (3.14) and substituting it in equation (3.15) and using (3.17) $\lambda_2 = 0$ and $\lambda_1 = -\frac{\partial V^G}{\partial W^S}$.

And replacing the values ofλ_1 and λ_2 in equation (3.13) and using the result of equation (3.17):

$$w_1 = \frac{\frac{\partial B}{\partial q} + \frac{\partial B}{\partial S}|q}{1 + \frac{\partial S}{\partial q}}$$

The result found for w_1 suggests that this parameter represents the sum of the variation of the benefit function plus a more effective measurement of the same function with respect to the maintenance function provision costs. This sum is divided by a sort of percentage variation of the quantity, in this case, only taking into account how the maintenance costs are affected by this variable.

Analysis of result 3:

When the government hires maintenance servicing companies the moral hazard problem appears. In subscribing the PPP contract, the public entity can observe the quality of the items that will be used to perform the maintenance services. In return, the State cannot adequately monitor the proper use of this equipment. This is, if after the signing of the contract, the maintenance companies marginally change their parameter q, i.e. if the employees marginally change their level of effort, the cost impact may be barely noticeable, but the quality of the services will be reduced. In this case, the *second-best* condition is attained, precisely because the government faces the monitoring problem.

3.2.4 Scenario 4: The state hires the construction company and this sub-contracts the maintenance company

In this scenario the State, in partnership with a consortium that is the company which will be responsible for building the hospital, subcontracts the firm that will provide maintenance services. Here it is assumed that the contractor will effectively monitor the firm responsible for the maintenance, because it is concerned with the quality of service in favour of maximizing their profits. Then the maximization problem of the construction company is the following:

$$Max\, W^H = V^H\left(B(x,q,k), \Pi^H\right)$$

subject to

$$W^S = V^S\left(B(x,q,k), \Pi^S\right) \geq \overline{V} \text{ [Participation Constraint]}$$

Where:

The objective function of the construction company is: $W^H = V^H\left(B(x,q,k), \Pi^H\right)$;

The linear payment made by the government to the construction company:$T = b_0 + b_1\left[S(q,k) + \Omega\right]$;

Payment rule associated with a subcontract: $\Omega = w_0 + w_1 S(q,k)$;

Construction companies profit: $\Pi^H = T - H(k) - \Omega = b_0 + (b_1 - 1)\left[H(k) + w_0 + w_1 S(q,k)\right]$;

Maintenance companies profit:$\Pi^S = \Omega - S(q,k) = w_0 + (w_1 - 1)S(q,k)$;

This problem could be solved using Lagrange multipliers:

$$L_{\{k,q,w_0,w_1,\lambda_1\}} = V^H + \lambda_1 \left[W^S - \overline{V} \right]$$

Obtaining the FOC:

$$\frac{\partial L}{\partial k} = \frac{\partial V^H}{\partial B}\frac{\partial B}{\partial k} + \frac{\partial V^H}{\partial \Pi^H}\frac{\partial \Pi^H}{\partial k} + \lambda_1 \frac{\partial W^S}{\partial k} = 0 \tag{3.18}$$

$$\frac{\partial L}{\partial q} = \frac{\partial V^H}{\partial B}\frac{\partial B}{\partial q} + \frac{\partial V^H}{\partial \Pi^H}\frac{\partial \Pi^H}{\partial q} + \lambda_1 \frac{\partial W^S}{\partial q} = 0 \tag{3.19}$$

$$\frac{\partial L}{\partial w_0} = \frac{\partial V^H}{\partial \Pi^H}\frac{\partial \Pi^H}{\partial w_0} + \lambda_1 \frac{\partial W^S}{\partial w_0} = 0 \tag{3.20}$$

$$\frac{\partial L}{\partial w_1} = \frac{\partial V^H}{\partial \Pi^H}\frac{\partial \Pi^H}{\partial w_1} + \lambda_1 \frac{\partial W^S}{\partial w_1} = 0 \tag{3.21}$$

$$\frac{\partial L}{\partial \lambda_1} = W^S - \overline{V} = 0 \tag{3.22}$$

Isolating λ_1 in (3.20) we have: $\lambda_1 = -\frac{\partial V^H}{\partial W^S}$.

Replacing $\lambda_1$in equation (3.21) and solving it for w_1:

$$w_1 = -\frac{\partial H}{\partial S}$$

The next step is to substitute λ_1 in equation (3.18) and solving it to b_1:

$$b_1 = 1$$

Analysis of result 4:

If the government establishes a PPP contract with a construction company that hires a sub-servicing maintenance company, assuming that the former is able to monitor the quality of service provided by the second, we have that w_1 represents the variation between the function costs of the firms. Furthermore, the most interesting result is that of $b_1$being equal to 1, which makes the construction business profit[14] equal to parameter b_0 This may indicate that the building company is not being able to perform the effective monitoring of the maintenance service company; consequently the developer only receives the minimum amount for it to keep producing. Here, we have the *second-best* situation, but the construction company is faced with a limitation and could choose not to internalize the activity of maintenance services. Bellow, there is a table summarizing the main results of all above scenarios:

Bellow, there is a table summarizing the main results of all above scenarios:

[14] $\Pi^H = T - H(k) - \Omega = b_0 + (b_1 - 1)\left[H(k) + w_0 + w_1 S(q,k)\right]$, if $b_1 = 1$ then $\prod^H = b_0$

Tabela 1: Main results of the adapted model

Scenario	Result	Parameter	Comment
1. Hiring of Clinical Services	If the changes in q after the signing of the contract are not perceivable by the government, the moral hazard problem appears.	$a_1 = \dfrac{\dfrac{\partial B}{\partial q} + \dfrac{\partial B}{\partial C}\Big\|_q}{1 + \dfrac{\partial C}{\partial q}}$	If the health care professionals marginally change their effort level, the costs impact could be little perceptible, but the service quality will be reduced.
2. Hiring of the Contractor	If the government can monitor the quality service of the construction company, the *first-best* situation is achieved.	$b_1 = \dfrac{\partial B}{\partial H}$	This result is efficient.
3. Hiring of the Servicing Company	If after signing the contract, the maintenance companies marginally alter their parameter q, the cost impact may be barely noticeable, but the quality of the services will be reduced.	$w_1 = \dfrac{\dfrac{\partial B}{\partial q} + \dfrac{\partial B}{\partial S}\Big\|_q}{1 + \dfrac{\partial S}{\partial q}}$	In that case, it reaches the *second-best* condition, precisely because the government faces the monitoring problem.
4. Building company outsources the service company.	Even with the assumption of an effective monitoring, the moral hazard situation appears implicitly.	$-\dfrac{\partial H}{\partial S} = w_1$ e $b_1 = 1$	If the construction company knows the result beforehand, it could choose not to centralize the contract.

Source: Authors

4 Final Remarks

The purpose of this work was to analyze different contract scenarios for the formation of Public-Private Partnerships for hospitals in Brazil. This was done by drawing on the model of Barros and Giralt (2009), adapting it to the Brazilian institutional structure.

In this sense, when there is the carrying out of a PPP, with the companies providing clinical or maintenance services, the moral hazard problem turns up. Then, the public entity must seek alternative ways to monitor or follow up the services provided by these professionals.

However, even with this difficulty, the benefits of adopting this contractual arrangement may be higher than the ones associated with the hiring of public workers. In the case of clinical service providers, this happens because of the high costs of updating professionals, especially due to the need of achieving new skills. But, when focusing on maintenance companies, the costs associated with outsourcing this service are lower, compared to the hiring of a public worker.

In relation to construction and maintenance companies, a separate contract proved to be more efficient for the government. Even considering that the construction company manages to monitor the quality of the maintenance service companies, the moral hazard problem appears implicitly when resolving the maximization problem. In this case, the decentralization of contracts appears as more efficient; however the state must protect itself by taking precautionary measures to reduce contractual risks.

In short, as the information economic theory highlights, the moral hazard problem influences the results arising from the scenarios analyzed in this study. That is, the formation of PPPs for the building of new hospitals in Brazil will require government efforts, particularly related to monitoring of the projects progress and contractual terms, with well-structured contract clauses for the protection of the public interest.

In short, as the information economic theory highlights, the moral hazard problem influences the results arising from the scenarios analyzed in this study. That is, the formation of PPPs for the building of new hospitals in Brazil will require government efforts, particularly related to monitoring of the projects progress and contractual terms, with well-structured contract clauses for the protection of the public interest.

Finally, for the upcoming research agenda, it would be interesting to evaluate the time horizon in the formation of these contracts, since these partnerships are characterized by longer contracts and also, focus on technological progress, which affects the health sector heavily.

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